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EFFECT OF HORMONES ON THE GROWTH, SPORE SIZE AND SEPTATION OF SPORES OF *ALTERNARIA TENUIS*

By

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(Received on 25th February 1958)

Hormones are known to play a great part in the life of all living things. The effect of external supply of certain hormones on the growth and morphological features of *Alternaria tenuis* was, therefore, studied.

MATERIALS AND METHODS

The basal medium selected for the present investigation was Asthana and Hawker's medium A (glucose 5 gms., KNO_3 3·5 gms., KH_2 PO_4, 1·75 gms., $MgSO_4$, 7 H_2O, 0·75 gm. and distilled water 1 litre).

Autoclaving was carried out at 15 lbs pressure for 15 minutes. The inoculated cultures were incubated for 15 days at room temperature.

All precautions customary to hormone experiments were rigidly observed. Pyrex glassware were thoroughly washed with double distilled water, and the nutrient solution was purified by Steinberg's process (1935). Fifteen gms. of basic magnesium carbonate was added to a litre of the basal medium and the mixture was heated in an autoclave at 10 lbs. pressure for 20 minutes. The mixture was allowed to stand overnight and the solution was filtered. Indole- 3- acetic acid, 2, 4-dichloro- phenoxy acetic acid, alpha naphthalene acetic acid, methyl 2-naphthoxy acetic acid, indole -3-butyric acid and indole propionic acid were added to 40 c.c. of the solution at concentrations of 0·001, 0·0001 and 0·00001% before the second autoclaving. Inoculations were made from spore suspensions of the organism prepared in double distilled water.

OBSERVATIONS

It was noticed that the mycelial growth was stimulated by 0·00001% methyl 2—naphthoxy acetic acid and 0·0001% indole propionic acid.

TABLE 1

Dry weight and mean size of the spores of *A. tenuis* in solutions containing different hormones.

IAA (indole-3-acetic acid); DPA (2,4. dichlorophenoxy acetic acid); MNA (methyl-2-napthoxy acetic acid) NAA (alpha naphthalene acetic acid); IBA (indole-3-butyric acid) & IPA (indole propionic acid.)

Hormones	%	Dry weight	Mean size of different types of spores in μ			
			Muriform	Uniseriate	Bicelled	Unicelled
IAA	0·001	0·014	25·32×15·04	25·85×10·81	14·1 × 7·05	8·6 × 8·6
	0·0001	0·0804	27·26×14·1	24·42 × 7·99	14·1 × 7·05	9·4 × 9·4
	0·00001	0-1042	26·32×14·57	26·32×12·69	14·1 × 7·05	9·4 × 9·4
DPA	0·001	0·0970	30·08×15·51	25·85 × 8·46	12·69×7·99	10·34×9·2
	0·0001	0·0854	27·26×17·63	28·2 × 10·34	15·51×7·99	9·4 × 9·4
	0·00001	0·0705	28·2 × 16·45	28·2 × 9·4	15·98×9·4	9·4 × 9·4
MNA	0·001	0·0692	28·2 × 16·04	23·5 × 9·4	12·69×9·4	10·37×9·4
	0· 0001	0·0960	28·2 × 16·04	26·79 × 9·4	15·98×10·37	10·81×9·4
	0·00001	0·1019	24·9 × 17·63	24·91×10·37	10·37×10·37	9·4 × 9·4
NAA	0·001	0·0776	30·08×15·98	21·42 × 7·79	12·69×10·37	9·4 × 9·4
	0·0001	0·0888	28·2 × 16·04	23·5 × 9·4	14·1 × 10·37	9·4 × 9·4
	0·00001	0·0920	28·2 × 14·1	23·5 × 10·37	14·1 × 10·37	9·4 × 9·4
IBA	0·001	0·0964	23·5 × 17·63	23·86 × 9·4	14·1 × 10·37	9·4 × 9·4
	0·0001	0·0764	26·79×15·51	24·72×10·37	14·1 × 10·37	9·4 × 9·4
	0·00001	0·1017	27·26×15·51	24·8×10·37	13·98×9·4	9·4 × 9·4
IPA	0·001	0·0374	27·26×17·86	25·85×11·75	12·69×7·99	9·4 × 9·4
	0·0001	0·0948	24·91×17·86	27·26×11·75	15·51×7·99	9·4 × 9·4
	0·00001	0·0959	27·26×16·06	28·2 × 12·69	12·69×7·99	9·4 × 9·4
Control		0·1072	28·5 × 16·1	24·8 × 9·4	14·69×9·4	9·4 × 9·4

The percentage of different types of spores is shown in Fig 1.

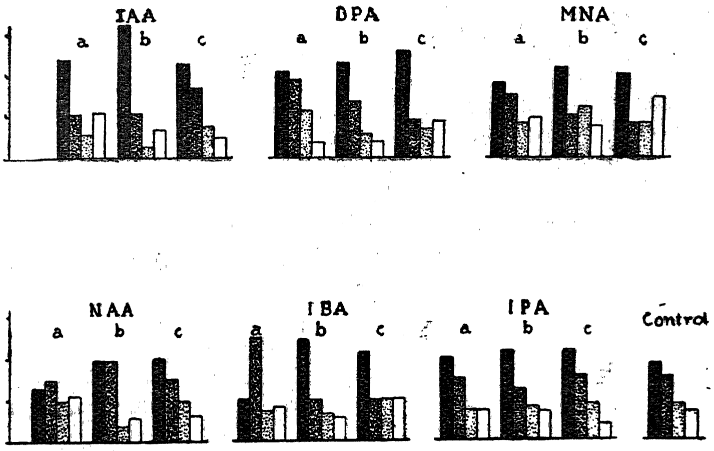

Fig. 1 The percentage of different types of spores of A. tenuis on media containing different hormones

Muriform
Uniseriate
Bicelled
Single celled

IAA - Indole-3-acetic acid
DPA - 2.4-Dichlorophenoxy acetic acid
MNA - Methyl 2-naphthoxy acetic acid
NAA - Alpha naphthalene acetic acid
IBA - Indole butyric acid
IPA - Indole propionic acid

a = 0·001%
b = 0·0001%
c = 0·00001%

Fig. 1 shows that the muriform spores predominated in all cases except in 0·001% alpha naphthalene acetic acid and indole-3-butyric acid. The percentage of muriform and uniseriate spores was similar at 0·0001% alpha naphthalene acetic acid. In general fewer muriform spores were developed at higher concentrations of the hormones viz. at 0·001%. This was markedly pronounced in case of 0·0001% naphthalene acetic acid and indole butyric acid. This further confirmed the previous results obtained with trace elements where the development of longitudinal septa was prevented or delayed on media which failed to support good growth.

The dry weight of the fungus and the mean size of the spores at different concentrations of the hormones are given in Table 1.

The table shows that none of the hormones stimulated growth. In fact their higher doses viz. 0·001% and 0·0001% were invariably harmful. Most marked adverse effect was observed with indole propionic acid.

It was also observed that the size of muriform spores was adversely influenced by 0·001% indole-3-butyric acid where the length was reduced from 28·5μ to 23·5μ. Minor variations were observed in other cases also but the differences were insignificant. The largest uniseriate spores were developed at lower concentrations viz. 0·0001% and 0·00001% of 2, 4- dichlorophenoxy acetic acid and 0·0001% indole propionic acid. Bicelled spores were largest on 0·00001% 2, 4-dichlorophenoxy acetic acid.

CONCLUSIONS

The present work revealed that 0·001% or 0·0001% hormones were invariably toxic to the fungus. Leonian and Lilly (1937), Murdia (1939) and Bhargava (1946) also found that high concentrations of heteroauxin were toxic and inhibited the growth of fungi studied by them. Even the lower concentrations failed to stimulate growth. Wolf studied the influence of varying concentrations of alpha naphthalene acetic acid on *Achlya bisexualis* and *Saprolegnia ferax* but he did not observe any acceleration of growth. Richards (1950), however, reported that the effects of four hormones viz. indole-3-acetic acid, alpha-naphthalene acetic acid, 2, 4 dichlorophenoxy acetic acid and 2, 4, 5-trichlorophenoxy acetic acid were either stimulatory or inhibitory. As a general rule inhibition occurred within the concentration range of 10^{-3} —10^{-4} molar. The present investigations confirm that the above hormones did not accelerate the growth at concentrations ranging between 0·001%, 0·0001% and 0·00001%. Even the lowest concentration of 2, 4-dichlorophenoxy acetic acid decreased the growth though in other cases there was no significant difference from the control but the stronger doses viz. 0·001% and 0·0001% were positively toxic to the fungus because the growth was retarded, the sporulation was considerably suppressed and the average size and septation of spores were decreased.

REFERENCES

1. Bhargava, K. S. 1946 ... Physiological studies in some members of the family Saprolegniaceae v. Growth substances. Lloydia 9:13-23.
2. Leonian, L. H. and Lilly, V. H. 1951. Is heteroauxin a growth promoting substance? Amer. Jour. Bot. 24:135-137.
3. Murdia, M. S. 1939 ... Effect of indolyl-3-acetic and phenyl acetic acid on the growth of some members of the family Saprolegniaceae. Curr. Sci. 8:362-363.
4. Richards, R. R. 1949 ... Responses of representative fungi to certain growth regulating substances. Bot. Gaz. 110:523-550.
5. Steinberg, R. A. 1935 ... Nutrient solution purification for removal of heavy metals in deficiency investigations with *A. niger*. Jour. Agr. Res. 51 : 413—424.

ROOT HABIT IN RESPONSE TO EROSION, SILTING AND INUNDATION

By

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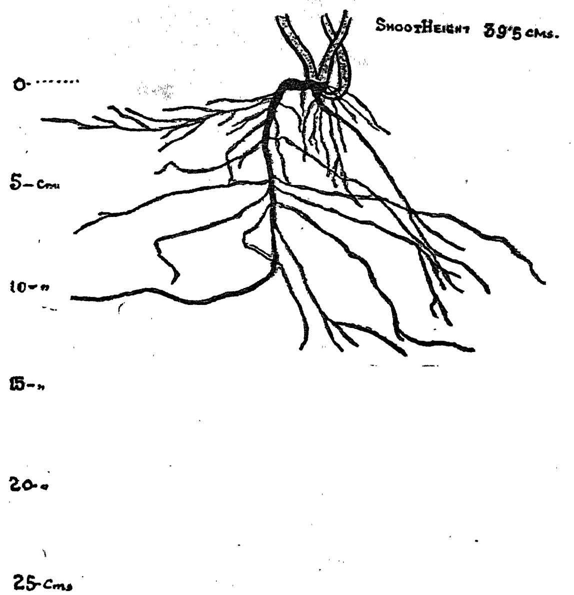
(*Department of Botany, Banaras Hindu University*)

Read at the 27th Annual Session of the Academy held at the University of Jabalpur on 27th December 1957

Effect of erosion, silting and inundation on the development of root systems of some plants in alluvial soils of Varanasi has been studied. The plants examined were of sufficiently mature stage. In case of herbaceous plants under normal conditions the main tap root goes down curving round pebbles and gives rise to rootlets uniformly throughout their length.



EUPHORBIA HIRTA

Fig. 1. Normal root system.

In *Euphorbia hirta* (erect form) (Fig. 1) the normal root depth is approximately one third of the shoot height. When subjected to mild erosion the main root as well as few lateral ones become thick and hard. On gentle slopes the roots (Fig. 2) go deep down generally to half the length of shoot. On steeper slopes with moderate erosion the roots tend to grow more laterally and thus retard sheet erosion. In localities as

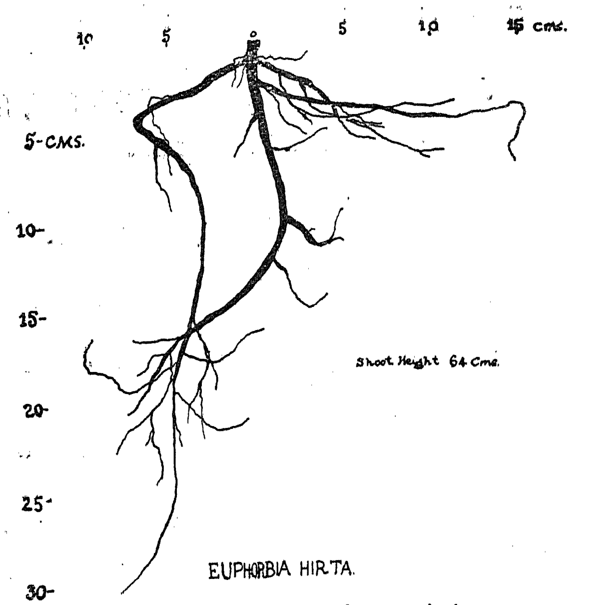


Fig. 2. Root system from gentle slope.

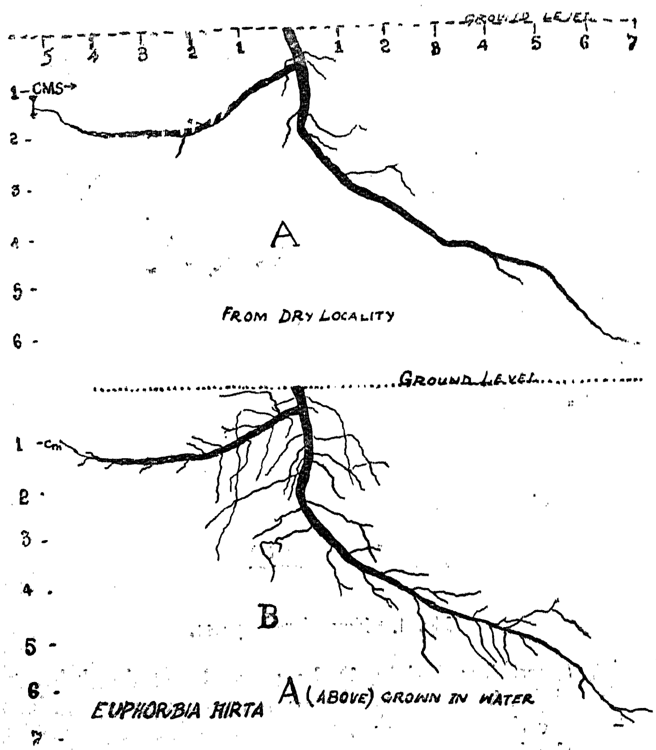
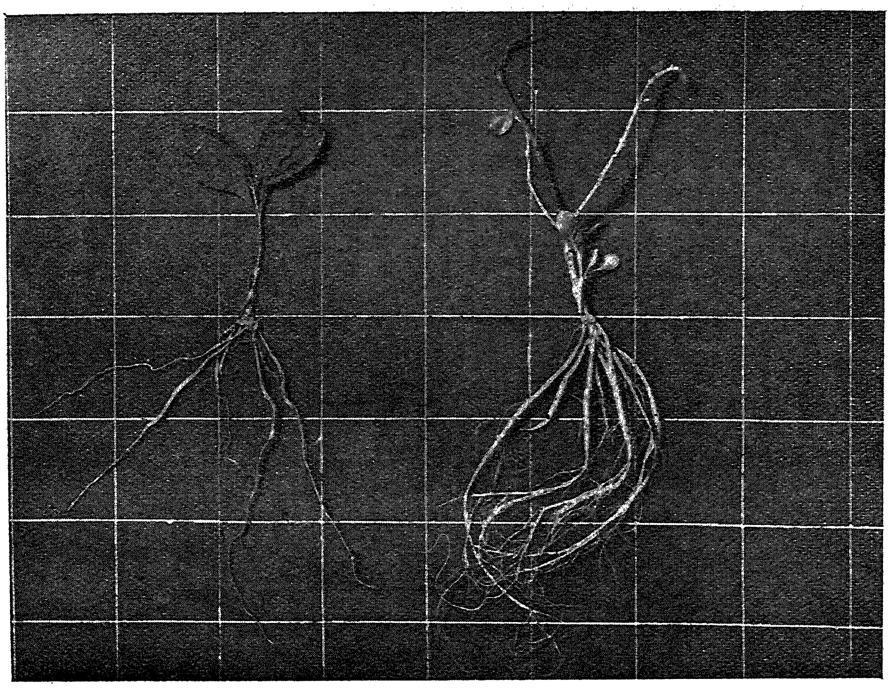


Fig. 3. (A) showing normal root development in dry locality.
(B) The same i. e. (A) when grown in water showing profuse root branching.

Rajghat ravines where the monsoon erosion is severe leaving coarse sand and pebbles on the surface, the degree of root branching is high and even the finer rootlets become brown very soon. Similar response in root growth is also found in waterlogged localities (Fig. 3), but the rootlets are lighter in colour. In fact the growth in water culture is profuse and white.



Ruellia tuberosa.

Fig. 4. Photograph showing a profuse root branching when grown in water culture as compared to normal root development (on left) in mesophytic condition.

In waterlogged soil *Ruellia tuberosa* (Fig. 4) has moderately branched root system but when grown in water culture the root response is like that of *Euphorbia hirta*. A very large number of long white rootlets arise and in about twentv days of submergence the whole root system gets covered with thread like rootlets. Both the thick brown and the thin white roots contain large number of air spaces.

Increase in extent of finer rootlets is also common in *Phyllanthus niruri* when grown in waterlogged conditions.

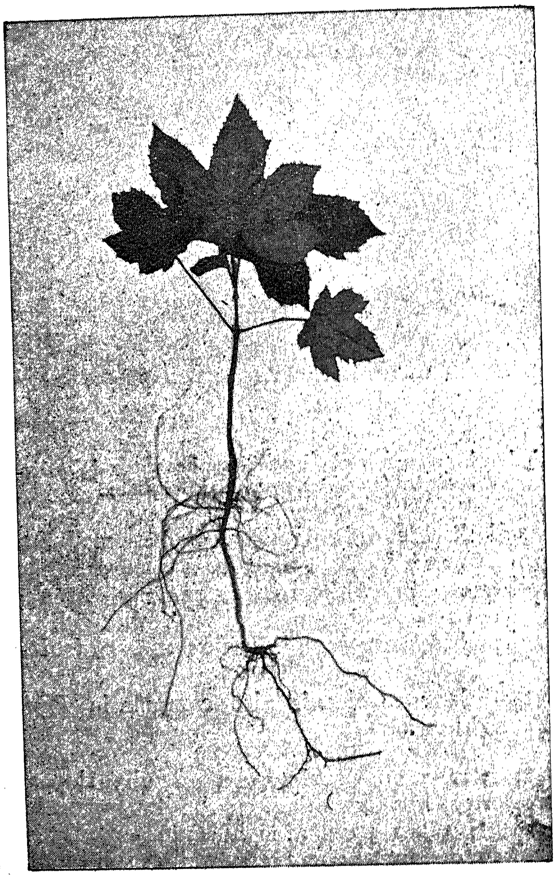
In *Corchorus acutangulus* the root development on gully slopes at Rajghat ravines subjected to severe erosion is less extensive on the face parallel to the surface as abundant growth of rootlets takes place at right angle to it. This type of development is obviously advantageous for anchorage as well as soil binding.

Amongst other plants *Crotalaria medicagenea* has deep root inclined in the direction away from the slope which is helpful in anchorage but not in checking erosion. In *Achyranthes aspera* it has been observed that under slow erosion the stems

keep pace in giving rise to new roots from nodes, but in severe erosion they fail to bind any amount of soil, and almost whole of the root systems get exposed. Sometimes one or two rootlets just hold the plant from falling, but it slowly dies as these few rootlets are not enough to supply the minimum needs of the plant.

Besides the herbs many trees as *Millingtonia hortensis* and *Pongamia glabra* and spiny thickets of *Capparis sepiaria* show propagation by buds arising from the exposed roots. In these cases roots are adapted to propagate the plant and to check erosion. Their roots bind the soil, and when exposed anywhere by soil erosion they develop buds which quickly give rise to new shoots and simultaneously a fresh intensive growth of roots.

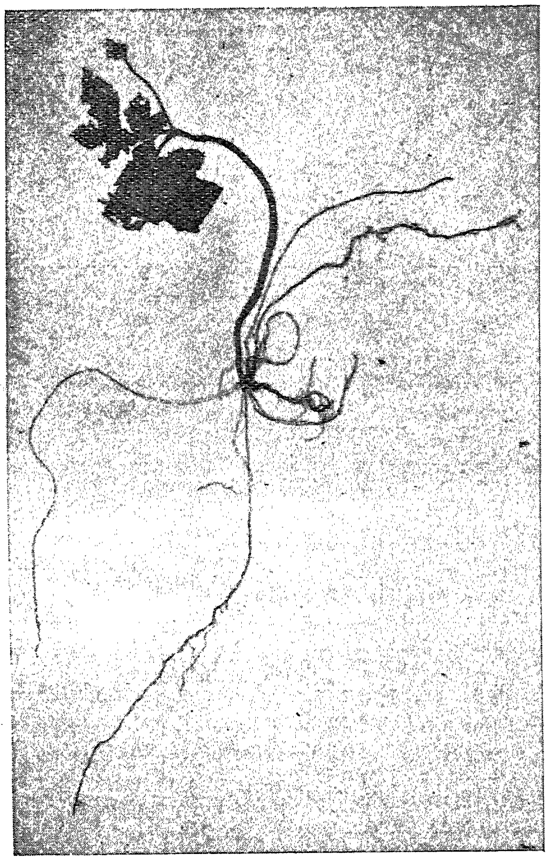
The effect of silting has been best noticed in *Ricinus communis* seedlings growing in abundance during early monsoon along the banks of Ganga. When siliting has taken place a fresh whorl of rootlets arise from the main stem at a distance (from the previous whorl) equal to the thickness of silting (Fig. 5). So such two whorls of



Ricinus communis.

Fig. 5. From silted locality showing two whorls of root branches.

rootlets in *Ricinus communis* seedling not only indicate silting, but also actual thickness of it. It has otherwise a single zone from which small rootlets arise. If it happens to grow at places subjected to erosion the rootlets become very long and traverse in all directions horizontally (Fig. 6).



Ricinus communis.

Fig. 6. From eroded locality.

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I am profoundly grateful to Professor R. Misra for his valuable guidence and encouragement throughout the course of this work. Thanks are also due to the Government of India for granting a Senior Research Scholarship which facilitated to a great extent in carrying on the work.

STUDIES ON THE UNDERGROUND PARTS OF *ALHAGI CAMELORUM*, FISCH.

By

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(Department of Botany, Banaras Hindu University)

Read at the 27th Annual Session of the Academy held at the University of Jabalpur on 27th December 1957

Alhagi camelorum, Fisch., a small herbaceous plant about 50 cms. tall grows abundantly on the banks of River Ganga at Varanasi. During summer days when other herbaceous plants on the dry sand die, this species reaches its maximum luxurience. It flowers in May and fruiting is over by the arrival of the Monsoon. For some period the dispersal may be by strong wind which blows away the sand, also later when the river is in floods, the twigs bearing fruits are carried to long distances by current of water. In Southern Russia it has been recorded by Kerner (quoted by Ridley, H. N., 1930) that the stem bases decay during fruiting season. These dry aerial parts full of spines get hooked and entangled as they roll along, until at length they form a ball as big as a cartload of hay. Such balls have been seen lifted up by whirlwinds and driven bounding over the plain. However, here the wind does not appear to be so active a dispersing agent.

During the rainy season the aerial shoots completely die and after floods and rains are over and inundated areas are exposed, fresh aerial shoots come up. A fairly extensive search was made for seedlings, but none could be found so far, and all the new aerial shoots happen to have arisen from underground perennating parts. The seeds possibly die when subjected to waterlogging in this region. Experiments will be conducted to check this hypothesis.

The underground parts go deep enough to reach moist zones (Soil moisture 12—15%), and thus the plants do not suffer from desiccation. These consist of a horizontally running root system which gives rise to upright stems within the soil. They traverse vertically up often upto two meters or more to reach the soil surface, and as soon as a node with bud gets exposed, a leafy shoot is given out. The habit of the plant thus suits the habitat subject to erosion and silting, both of which are quite severe during the rainy season at the river banks. At places of heavy silting the aerial shoots are buried deep and the leafy branches die and decay, while the main stem starts growing actively until the surface is reached. Here it gives new aerial leafy shoot. The newly exposed upright stems also die at heavily eroded localities and the buds adjoining the soil surface shoot out. Thus the plant thrives at situations exposed to intensive physiographic changes due to erosion and silting. It is only during the period of inundation that the aerial part altogether decomposes. The underground parts at this time perennate. Anatomical observations show a heavy starch reserve.

Laboratory experiments have so far indicated that the vegetative propagation of the plant is possible by parts which include both root and stem bits or root bits alone.

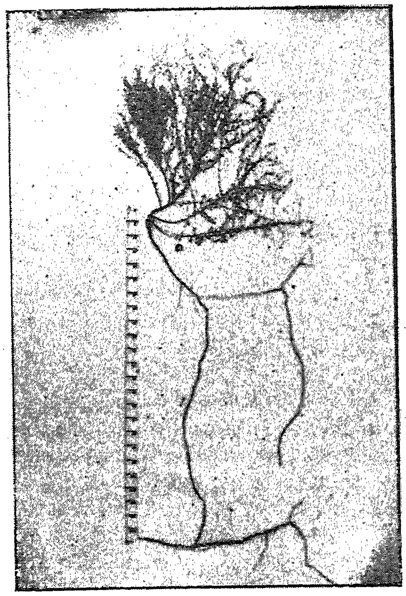

Fig. 1. *Alhagi camelorum.* Photograph of the underground parts showing horizontal and vertical systems. [Scale 120 cms.]

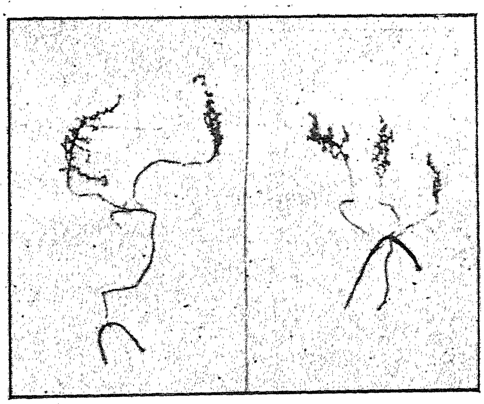

Fig. 2. Photograph showing new shoots coming up from thick old perennating underground part.

Fig. 3. Diagram of a piece of underground stem covered with buds.

ACKNOWLEDGEMENTS

I am profoundly thankful to Professor R. Misra for his valuable guidence and constant encouragement throughout the course of the work. Thanks are also due to the Government of India for having granted a Senior Research Scholarship which facilitated greatly in carrying on the work.

REFERENCE

Kerner, A. Natural History of Plants (Translated by F. W. Oliver, 1894) quoted by Ridley, H. N. 1930—'Dispersal of plants throughout the world'

STAGES OF TRANSITION IN THE AFFERENT BRANCHIAL ARTERIES FROM FISH TO AMPHIBIAN STAGE : A CASE OF PARALLEL EVOLUTION

By

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Read on 27th December 1957

INTRODUCTION

The modern view of the line of evolution from Fish to Amphibia, as Young (1952) puts it, is from aquatic Osteolepid fish through Stegocephalians to land Amphibia. As he writes "There are such close resemblences between the skulls of the earlier Amphibia and those of the Devonian Crossopterygian (Choanichthyes) fishes, that there can be no doubt of their relationship. *At present there is, however, no detailed fossil evidence of the stages of transition from the one type to the other.*" Again Westoll ('43) states "It is highly probable that Rhipidistia (=Osteolepidoti) had well developed air-bladders, since these are present not only in their Coelacanth descendants and (as lung) in tetrapods, but also in the living Diponi whose Devonian ancesters were derived from the same stock as Crossopterygians. Unfortunately, *this series is based only on fossils where only the evolution of the skeleton can be traced.*"

Although no fossil data on soft parts exists, the transformation from the fish stage to the amphibian stage must have entailed a series of intermediate stages in which there was stage by stage shift and fusion of the originally separate aortic arches of the fish and finally the obliteration of the fifth aortic arch. Recently, while working out the circulatory system of certain air-breathing fishes, we were struck by the stage by stage shift and fusion of the originally separate afferent arteries, which leads to a condition comparable to the stage found in the amphibian tadpole. The series of stages established by us is not strictly in the direct line of ancestory to the Amphibia, since the examples described belong to the Actinopterygii (Teleostei) and not the crossopterygii (Choanichthyes). No such series is recorded to our knowledge in purely aquatic teleosts. Nevertheless, along with functional parallelism on migration from water towards land, our air-breathing fishes show stage by stage shift and fusion of the afferent arteries, which may have obtained in the original ancestral series from Fish to Amphibia. Modification of structure due to functional parallelism has led here to the elaboration of a series in nature which appears to be a true case of parallel or convergent evolution. Although the living Dipnoi may show a similar parallel evolution of the air-bladder as "lungs" no such stage by stage shift and fusion ~~of~~ the afferent branchial arteries has ever been demonstrated.

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The circulatory system of fishes with accessory respiratory organs has not received detailed attention from workers either recent or past, and few workers have attempted to establish an evolutionary series from fish to Amphibia, so far as afferent branchial arteries are concerned. Amongst the early workers Hyrtl (1853) worked out the anatomy of *Saccobranchus singio* and *Ophiocephalus* sp., and Burne (1896) described the aortic arch system of *Sccobranchus fossilis.* Carter (1935) discussed the circulatory adaptations in relation to respiratory modifications in *Electrophorus electricus* and *Plecostomus plecostomus;* Das ('34, '40) described the structural adaptations in *Pseudapocryptes laneeolatus* and a few other fishes; Lele ('34) worked out the circulation of blood in the air-breathing chamber of *Ophicephalus punctatus;* Wu and Lin ('43) described the circulatory system of *Monopterus javanensis* ; While Wu and Weichang ('46) discussed the arterial supply of the gill and the supra-branchial chamber of *Ophicephalus argus.* In recent years Ghosh ('48) wrote a note on the afferent arteries of *Ophicephalus punctatus* and Das and Saxena ('54) reported some new observations on the circulatory system of *Ophicephalus striatus.* But to our knowledge no attention has been paid by any of the workers to the mode of origin of the afferent branchial arteries from the ventral aorta except Saxena ('54) on the afferent branchial system of *Heteropneustes fssilis* ; Nawar ('55) on the vascular system of *Clarias laZera* ; Saxena ('56 a, b, c) on the afferent branchial arteries of *Mastacembelus armatus, Anabas testudineus* and *Ophicephalus punctatus* ; Saxena ('56) on the aferent branchial system of *M. armatus, Rita rita,* and *A testudineus,* and Das and Saxena ('56) on the circulation of blood in the respiratory region of *Labeo rohita* and *Ophicephalus striatus.*

The present paper deals with the origin and arrangement of afferent branchial arteries in five fishes which show a gradual shift and fusion of the afferent arteries, as well as foreshortening of the ventral aorta, a condition leading to the amphibian stage. The fishes depicting these stages are: *Labeo rohita, Masatacembelus armatus, Clarias batrachus, Ophicephalus striatus,* and *Heteropneustes fossilis.*

Labeo rohita (Ham. Buch.)

The common India cyprinid *Labeo rohita,* a typical non air-breathing fish, has four pairs of afferent branchial arteries. The ventral aorta extends between the ventral ends of the fourth and the first branchial arches, and terminate by dividing into the first pair of afferent branchial arteries. The ventral aorta gives rise to the fourth pair of the afferent branchial arteries immediately after piercing the pericardium. Between the first and the fourth pairs of afferent branchial arteries, the second and third pairs of afferent branchial arteries are given off in level with the ventral end of the second and third branchial arches. All the four afferent arteries are similar and equidistant.

Each of the four pairs of afferent arteries originate by independent openings on the lateral walls of the ventral aorta (Fig. 1), and the four openings on each side are widely separated and equidistant.

Mastacembelus armatus (Lacepede)

In the spiny eel *Mastacembelus armatus* the ventral aorta extends from the pectoral girdle upto the ventral end of the first branchial arch where it terminates by dividing into the first pair of afferent branchial arteries. The ventral aorta gives out two pairs of arteries in level with the ventral end of the fourth branchial arch, the third and fourth. In between the third and first pair of afferent arteries the ventral aorta gives off the second pair of afferent branchial arteries.

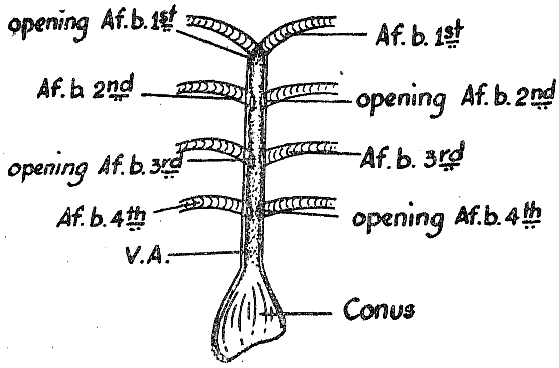

Fig. 1. The ventral aorta cut open to expose the origin of all the afferent arteries in *Labeo rohita.*

Af. *b.* 1st., 2nd., 3rd., & 4th.—First, Second, Third and fourth Afferent arteries ; V. A. Ventral aorta.

Each of the second pair of afferent arteries have a separate origin from the lateral wall of the ventral aorta in level with the ventral end of the second branchial arch. The fourth pair of afferent branchial arteries have their origin from the roof of the ventral aorta, each from a distinct aperture (Fig. 2). The openings of the

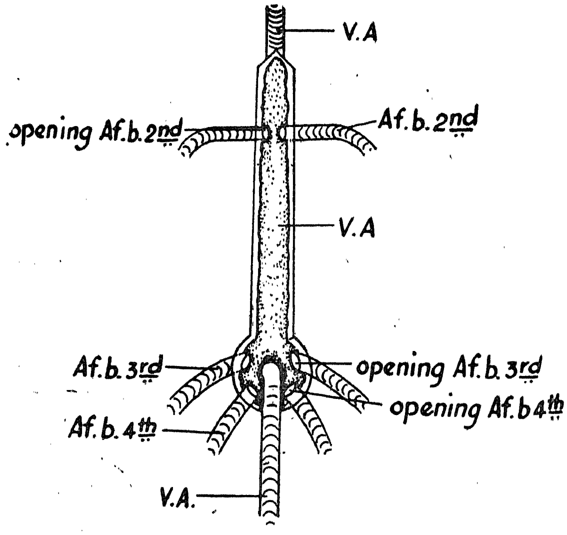

Fig. 2. The ventral aorta cut open to expose the second, third and fourth afferent arteries in *Mastacem belus armatus.*

fourth pair of afferent arteries are situated very close to each other. The third pair of afferent branchial arteries originate laterally from the ventral aorta, each from a separate aperture, being placed on each side of the openings of the fourth afferent arteries. All the four openings are situated closely.

Clarias batrachus L.

The ventral aorta extends between the ventral ends of the third and first branchial arches. It terminates by dividing into the first pair of afferent branchial anteries. The ventral aorta immediately after piercing the pericardium gives out two pairs of afferent branchial arteries, the third and fourth. In between the third and first pairs of afferent arteries the ventral aorta gives off the second pair of afferent branchial arteries in level with the ventral end of the second branchial arch.

The second pair of afferent branchial arteries originates dorso-laterally from separate openings in the ventral aorta. The third and fourth afferent arteries of each side arise from a common opening (Fig. 3) on the roof of the ventral aorta. Thus, the four arteries, the right and left third and fourth afferent arteries have a common origin from the ventral aorta.

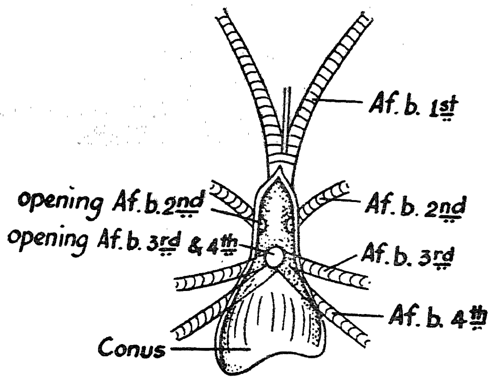

Fig. 3. The ventr al aorta cut open to expose the second, third and fourth afferent arteries in *Clarias batrachus.*

Ophicephalus striatus Bloch.

In the snakeheaded murrel *Ophicephalus striatus* the ventral aorta extends from the ventral end of the third branchial arch upto the mid-distance between the second and first branchial arches, where it terminates by dividing into the first pair of afferent branchial arteries. Along its course in level with the ventral end of the second branchial arch the ventral aorta gives off the second pair of afferent branchial arteries. The ventral aorta, in level with the ventral end of the third branchial arch, after piercing the pericardium gives off two pairs of afferent branchial arteries, the third and fourth.

The second pair of afferent arteries divides immediately after its origin from a single common aperture (Fig. 4) in the dorsal wall of the ventral aorta into the right and left second afferent branchial arteries. The third and fourth pairs of afferent arteries originate frcm a common opening on the roof of the ventral aorta. The third and fourth afferent arteries of each side arise from a common root, and the two common roots have a common origin from the ventral aorta.

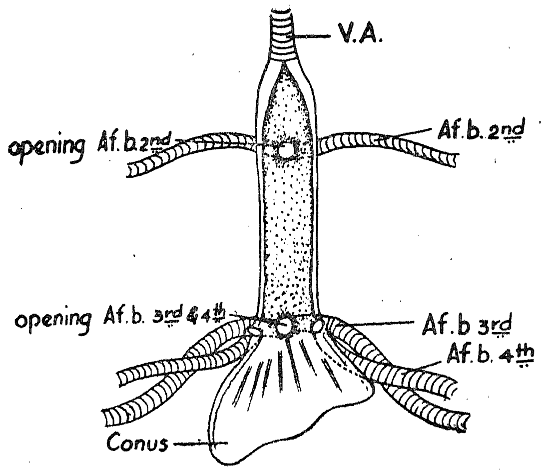

Fig. 4. The vental aorta cut open to expose the second, third and fourth afferent arteries in *Ophicephalus striatus*.

Heteropneustes fossilis Bloch.

The ventral aorta extending in between the ventral ends of the third and first branchial arches terminates by bifurcating into the first pair of afferent branchial arteries. The ventral aorta immediately after piercing the pericardium gives off two branches one directed forward and the second backward. The forwardly directed branch divides into two immediately after it is given out to form the sccond pair of afferent branchial arteries. While the second branch which is backwardly directed also divides into two, the right and left, and each one of them in turn divides again into the third and fourth afferent branchial arteries of its side.

The second, third and fourth afferent arteries all originate from the same opening on the roof of the ventral aoıta (Fig. 5). The third and fourth afferent

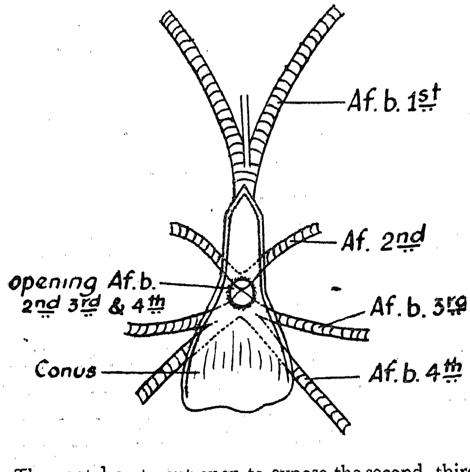

Fig. 5. The vental aorta cut open to expose the second, third and fourth afferent arteries in *Heteropueustes fossilis*.

arteries of each side arise from a common root. The two common roots of the third and fourth afferent arteries arise from a single aperture from which the common root of the second pair of afferent arteries also originate. Thus, the six arteries (the right and left second, third and fourth afferent arteries) in all originate from the ventral aorta by a single opening.

Rana tigrina Daud. (Tadpole 12mm.)

The conus arteriosus divides atonce into a right and a left branch, which runs striaght outwards on the floor of the pharynx. Each of these two branches divide, after traversing a short distance, into three vessels, the first, second and a common vessels dividing to form the third and fourth afferent branchial arteries. Thus there is a common opening for all the four pairs of afferent branchial arteries from the conus arteriosus (Fig. 6).

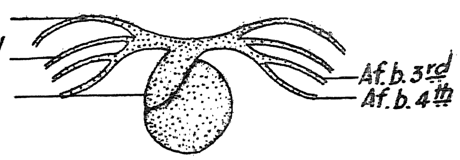

Fig. 6. Afferent arteries of Todpole of *Rana tigrina.*

DISCUSSION

The lack of oxygen in some tropical freshwaters has played a large part in the evolution of terrestrial vertebrates which no doubt have had a tropical freshwater ancestry. The power of breathing air must have been a necessary condition before the possibility of migration to land, although the stimilus for this adaptation must have arisen due to life in a medium poor in oxygen. The development of organs for aerial respiration in tropical freshwater fishes is a response to the shortage of dissolved oxygen in water. The aerial breathing modifications of the respiratory organs in fishes entail a change in the functioning of one or other of the main organ systems, which have brought about changes in the associated structures. The circulatory system, which is intimately connected with the respiratory organs has also become modified to meet the new demands.

Our studies on the branchial circulation in certain air-breathing fishes, led us to the discovery of the series discribed, in which there is stage by stage shift and fusion of the roots of the afferent branchial arteries, which lead to a condition similar to that found in the full grown amphibian tadpole.

In a typical non air-breathing fish such as the European *Salmo* or the Indian *Labeo*, there are four pairs of independent afferent arteries, each arising by its own opening (Fig. 7) from the ventral aorta. We have shown that there is juxtaposition of the openings of the third and fourth pairs of afferent arteries in *Mastacembelus armatus*. From this condition we may easily derive the common origin of the third and fourth pairs of afferent arteries seen in *Clarias* and *Ophiocephalus* (Das and Saxena '56); whereas in *Heteropneustes* the second, third and fourth pairs of afferent arteries, all originate from the same aperture in the ventral aorta. It would not be an exaggeration to state that a further advance along this line would lead us to the amphibian condition (as seen in a full grown tadpole larva of frog), where all four

pairs of afferent arteries have a common root, and the ventral aorta is reduced to form a conus. In Dipnoi also ventral aorta has shortened up to form the conus like amphibia.

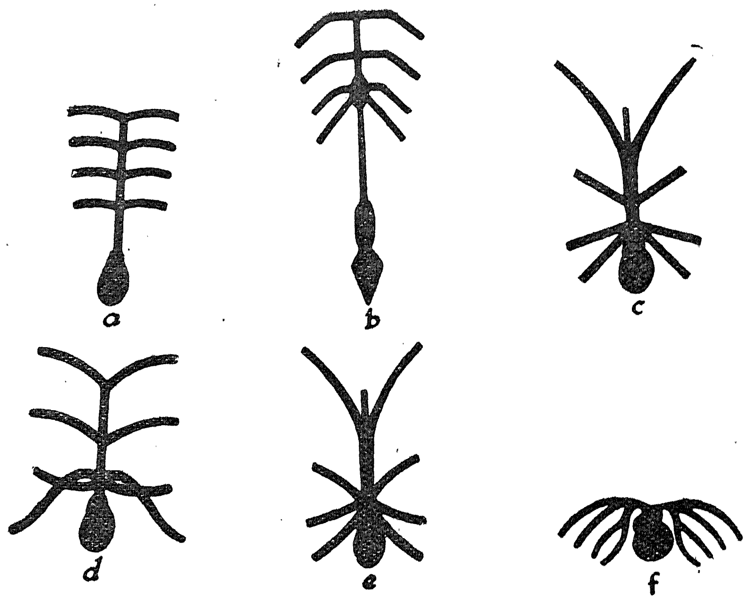

Fig. 7. Afferent arteries of (*a*) *Labco rohita*, (*b*) *Mastacembelus armatus*, (*c*) *Clarias batrachus*, (*d*) *Ophicephalus striattus*, (*e*) *Heteropneustes fossilis* and (*f*) 12 mm. tadpole of *Rana tigrina*.

We may thus conclude that this series probably shows a parallel case to what must have actually happened to the afferent branchial arteries in the evolution of Amphibia from Pisces, and that it affords a remarkable example of convergent (parallel) evolution due to functional parallelism.

SUMMARY

The important points in the present paper are :—

(1) All the four afferent arteries originate from independent openings in *Labeo rohita*;

(2) All the four afferent arteries originate from separate openings, but the openings of the third and fourth pairs of afferent arteries are situated close to each other in *Mastacembelus armatus*;

(3) The second pair of affairent arteries arise from separate openings, and the third and fourth pairs of afferent arteries originate from a single aperture in *Clarias batrachus*;

(4) The second pairs of afferent arteries arise from a single aperature and the third and fourth afferent arteries from another common aperature in *Ophicephalus striatus*;

(5) The second, third and fourth pairs of afferent arteries arise from a common aperture in *Heteropneustes fossilis*;

(6) The first, second, third and fourth pairs of afferent arteries arise from a common aperture in a 12 mm. tadople larva of frog (Rana tigrina);

(7) The series (Fig. 1–6, 7) affords a remarkable example of convergent evo-

lution due to functional parallelism, and shows us a parallel case to what must have actually happened in the evolution of Amphibia from Pisces, the successive stages being still exhibited in five fishes detailed above.

LITERATURE CITED

Burne, R. H. 1896 On aortic arch system of *Saccobranchus fossilis*. Jour. Linn. Soc. (London) Zool., 25 : 48.

Carter, G. S. 1935 Respiratory adaptations of fishes of the forest waters, with descriptions of the accessory respiratory organs of *Electrophorus electricus* (Linn.) (=Gymnotus electricus Audt.) and *Plecostomus plecostomus* (Linn.). Ibid. 39 (265); 219.

Carter, G. S. and L. C. Beadle 1931 Respiratory adaptations in fishes. Ibid. 37 (252) : 327.

Das, B. K. 1934 The habits and structures of *Pseudapocyptes lanceolatus* a fish in the first stage of structural adaptation to aerial respiration. Proc. Roy- Soc. London, Ser. B, Vol. 115 : 422.

——— 1940 Nature and causes of evolution and adaptation of air-breathing fishes. Proc. Indian Sci. Cong. Presidential address. 27 (2): 215.

Das, S. M. and D. B. Saxena 1954 Some new observations on the circulatory system of *Ophicephalus striatus* Bloch (Actinopterygii; Percomorphi). Current Sci, 23 (4) 127.

——— 1956 Circulation of blood in the respiratory region of fishes *Labeo rohita* and *Ophicephalus striatus*. Copeia, 1956 (2): 100.

Ghosh, G. S. 1948 On the afferent branchial arteries in *Opnicephalus punctatus*, Sci. and Culture, 13 (7): 293.

Hyrtl, J. 1853 Zur anatomie von *Saccobranchus singio*. Sitz. Akad. wiss. Bd. XI, Heft. 1 : 302.

Lele, S. H. 1934 The circulation of blood in the air-breathing chambers of *Ophicephalus punctatus* Bloch. Jour. Linn. Soc. (London) Zool., 38 : 491.

Nawar, G. 1955 On the anatomy of *Clarias lazera*: III. The vascular system. Jour. Morph., 97 (2): 179.

Saxena, D. B. 1954 New observations on the afferent branchial system of *Heteropneustes fossilis* Bloch. (Actinopterygii ; Ostariophysi ; Siluroidea). Current Sci., 23 (11) : 363.

——— 1956 a On the afferent branchial arteries in *Mastacembelus armatus*. Current Sci., 25 : 23.

——— 1956 b Arrangement of afferent branchial arteries in *Anabas testudineus*. Ibid. 25 : 87.

——— 1956 c On afferent branchial arteries in *Ophicephalus punctatus* Bloch. (Actinopterygii, Percomorphi). Sci. & Culture, 21 : 677.

——— 1956 On the afferent branchial system of *Mastacembelas armatus, Rita rita* and *Anabas testudineus* (Teleostomi). Proc. Nat. Acad. Sci. India, 26, B, Part II : 56.

Westoll, T. S. 1943 The orgin of tetrapods. Biol. Rev., 18 : 78.

Wu, H W. and C. K. Lin 1943 On the blood vascular system of *Monopterus javanensis*, an air-breathing fish. Sinensia, 14: 61.

Wu, H. W. and Hsiao Wei-chang 1946 On the arterial system of the gills and supra-branchial cavaties in *Ophicephalus argus* with special reference to the correlation with the bionomics of the fish. Sinensia, 17 (1/6) : 1.

Young, Z. A. 1955 The life of vertebrates. Oxford.

ON THE PHYTOSOCIOLOGICAL STUDIES OF *ANOGEISSUS LATIFOLIA* WALL. FORESTS OF MADHYA PRADESH

By

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Read at the 27th Annual Session of the Academy held at the University of Jabalpur

on 27th December, 1957

Anogeissus latifolia Wall. (Family-Combretaceae) is a widespread tree species distributed throughout India except Assam and Bengal. Outside India it occurs only in Ceylon (Troup, 1921). *Anogeissus latifolia* has been classed to belong to " miscelleneous " type of forests in this State (Misra, 1956). With a little lower frequency this species is also spread in Sal and Teak forests of Madhya Pradesh. However, it never forms a pure community.

Very little work has been done on the ecology of *Anogeissus latifolia.* The only work available on the subject is that of Troup (1921) who has given morphological description, distribution and economic importance of this species in his book " Silviculture of Indian trees ", vol. 2.

As far as the author is aware phytosociological studies of *Anogeissus latifolia* forests have not yet been attempted.

The literature available on *Anogeissus latifolia* pertains mainly to the seeds and their germination. Thus Pearson (1908) and Tireman (1906) have shown that *Anogeissus latifolia* produces enormous amounts of seed every year but very little or none is fertile. Fertility, according to them, is obtained in drought years. Upon burning and removal of dense growth of *Lantana camara* regeneration is accelerated. Similarly, Jagdamba Prasad (1943) and Chaturvedi (1947) have tried to correlate annual rainfall with germination capacity. Rao (1934) has suggested certain means to break the sterility of seeds. Chourey (1953) has tried to determine average seed output of this species.

The present work, therefore, has been undertaken to study the physiognomy and pattern of distribution of this species in Madhya Pradesh forests and also to determine its ecological status. A plant community with its particular environment constitutes an entity which has its origin and development (Misra and Puri, 1957). The plants of a population mutually interact upon each other and upon the environment as a whole. The distribution of a species in a community is, therefore, a result of all these dynamic processes. Thus for studying ecology and life history of any species it becomes essential to study first the pattern of distribution in its natural environment.

METHODS OF STUDY

Forests have been studied by random quadrats and belt transects. 25 feet wide belt transects were run across the contours. At least ten belt transects were studied in each forest. The area of the quadrat was arrived at by species area curve (Oosting, 1948). Both analytic and synthetic characters have been studied.

Analytic characters, (Hansen, 1950; Braun Blanquet, 1932) in contrast to synthetic characters, are those features of a community which can be observed or measured directly in each stand. These include kinds and number of species, arrangement of species and individuals, vigour, form, number of individuals, height of plants, area, volume, growth rate and periodicity. Some of these characteristics can be measured more readily than others and are, therefore, classified as "quantitative", while those which are usually described are "qualitative".

In quantitative characters abundance, frequency and cover were studied. Abundance: is the number of plants of each species occuring in a quadrat. Frequency: pertains to the percentage of the total number of quadrats in which a particular species occurs. Cover: denotes the avarage area occupied by each species in a quadrat.

The quantitative characters have also been presented in polygraphs and density diagrams.

Polygraphs: (Fig. 1 and 3) A circle is divided into 3 equal parts by drawing 3 radii at equal distance. Abundance (A), frequency (F) and cover (C) are represented on each radius. These graphs give a clear picture of distribution.

Density diagrams: (Fig. 2 and 4) Raunkiaer's (1909) frequency diagrams are plausible only when different associations are compared, but they fail to account for the homogeniety present in different stands of the same association. In order to overcome the difficulties encountered with regard to Raunkiaer's frequency diagrams, density diagrams (Pandeya, 1953) were suggested. In this the species are as usual divided into five frequency classes of Raunkiaer (1934) viz:

Class	A......	0 to 20%	frequency
,,	B......	21 to 40%	,,
,,	C......	41 to 60%	,,
,,	D......	61 to 80%	,,
,,	E......	81 to 100%	,,

Next the percentage of area covered by all the species falling in a particular frequency class is multiplied by the total number of species present in that class. These are plotted on Y axis and frequency classes on X axis (Pandeya, 1953.)

In qualitative characters listing of species, sociability and height have been studied. Listing of species generally uncovers the associates of the plant under

POLYGRAPHS SHOWING ABUNDANCE(A), FREQUENCY(F) AND COVER(C) OF *ANOGEISSUS LATIFOLIA* IN TEAK AND SAL FORESTS OF M.P.

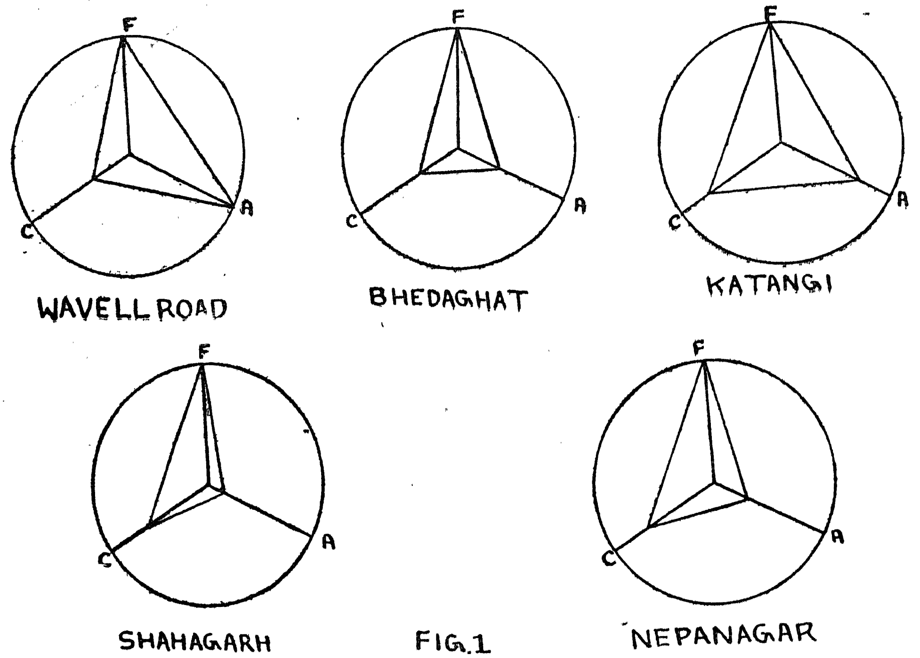
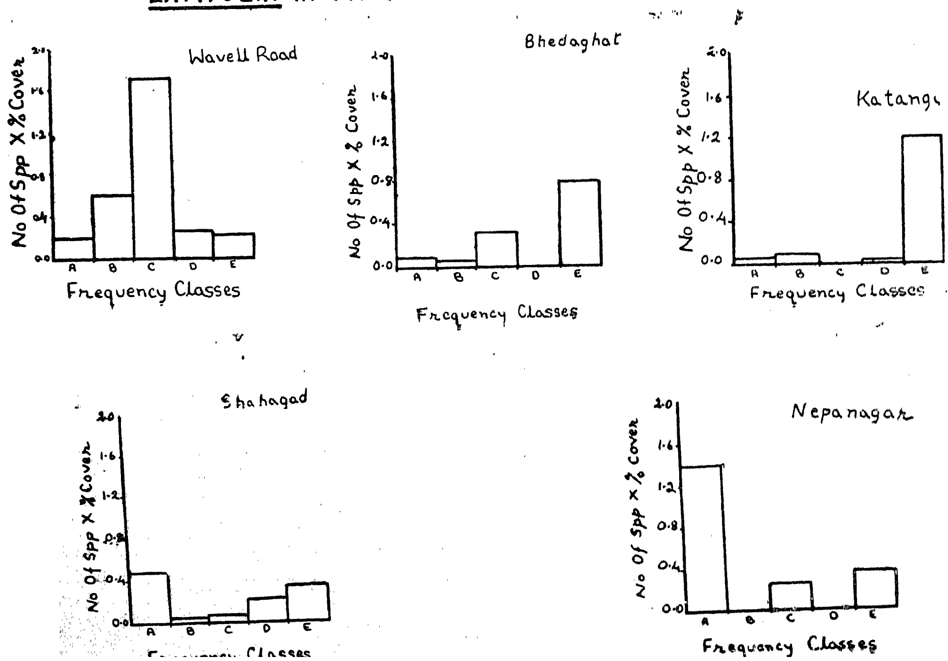


FIG.1

DENSITY DIAGRAMS SHOWING DISTRIBUTION OF *ANOGEISSUS LATIFOLIA* IN MISCELLENEOUS FORESTS OF M.P.



POLYGRAPHS SHOWING ABUNDANCE (A), FREQUENCY (F) AND COVER (C) OF ANOGEISSUS LATIFOLIA IN MISCELLENEOUS FORESTS OF M.P.

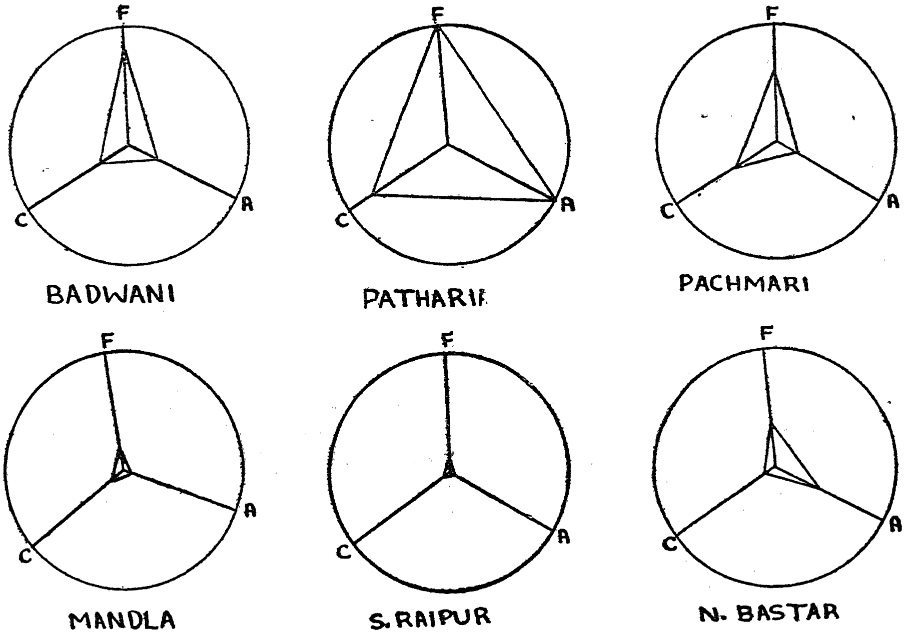


FIG 3

DENSITY DIAGRAMS SHOWING DISTRIBUTION OF ANOGEISSUS LATIFOLIA IN TEAK AND SAL FORESTS OF M.P.

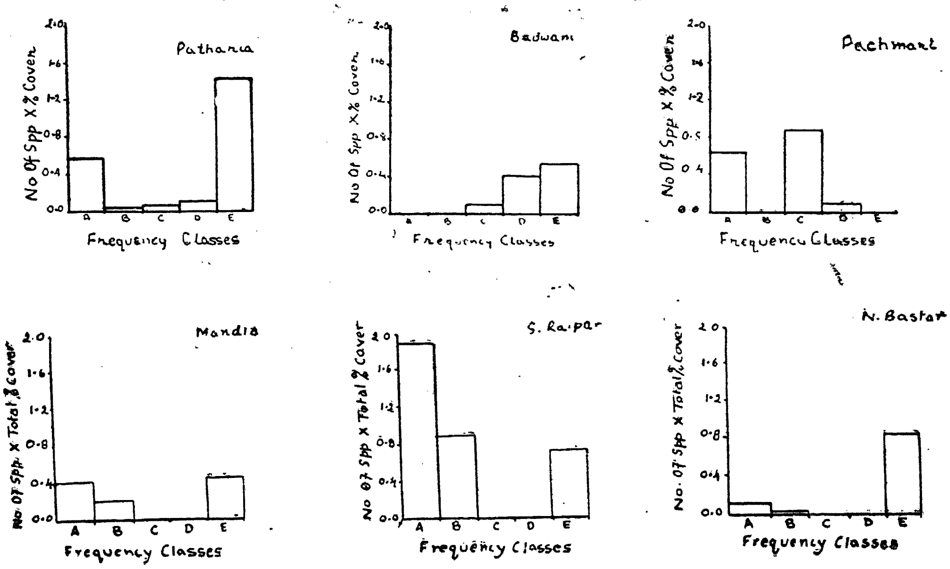


FIG 4

study. 'Sociability' refers to the space relationship of plants, or how closely together the individual plants or shoots grow (Hanson, 1950). Sociability is not a constant feature of a species but is generally determined by uniformity in the environmental factors such as competition and dependance. Seed productivity, their mobility and method of germination have a great influence on the way in which plants may be aggregated together.

Synthetic characteristics denote aspects of vegetation which are based on data obtained in the analysis of different regions. They tend to summerise and generalise some of the analytical characters. In these 'constance' and 'fidelity' were studied. Constance : deals with the degree of occurrence of the same species in different stands of a particular community; 'fidelity' represents the occurrence of a species in different community. 'Constance' will, therefore, give us some idea about the interrelations between stands of a community. It also gives some idea regarding the degree of regularity with which a species occurs in the stands observed in an association.

For the purpose of comparison three types of forests bearing *Anogeissus latifolia* were studied, viz. :—

(*a*) *Miscellaneous forests* :—In these forests there is no singular dominance. Probably these forests are still under succession. Such forests were examined on Wavell Road (Jabalpur), Narbada Ravines (Jabalpur), Katangi (Jabalpur), Shahagad (Sagar) district and Nepanagar (Khandawa). Some of these forests are open to intense grazing.

(*b*) *Teak forests* :—Teak is a dominant species in these forests. The forests of Badwani (Hoshangabad district) and Patharia (Sagar district) are some of the Teak forests which were examined for this study.

(*c*) *Sal forests* :—*Shorea robusta* dominates these forests. These are mostly towards eastern Madhya Pradesh. Out of these, forests of N. Bastar, S. Raipur, Mandla and Pachmari were examined.

PRESENTATION OF DATA

Phytosociological Characters :—

(A) *Miscellaneous forests* :—

(1) *Analytical characters* :—

(a) *Qualitative characters* :—Associates and height of the trees have been studied under these characters. *Associates* :—In all 32 species were found to occur in these forests. Out of these *Terminalia tomentosa* and *Carissa spinarum* are found in all the forests examined and are thus the constant species. The other important associates are *Zizyphus* sp., *Celastrus montana, Butea monosperma, Diospyros melanoxylon, Buchanania latifolia*.

Some of the species are found to be restricted to some regions only. Thus 'Sejo' is found only at Shahagad out of the regions studied. At Narbada Ravines *ixora sp* and *Vitis sp* are found, while at Wavell Road (Jabalpur) *Semicorpus anacardium* is found to be localised. The same is given in tabular form as follows :—

TABLE 1

Place		Total No. of species	Localised species
Wavell Road	...	18	*Semicarpus anacardium*
Narbada Ravines	...	14	*Ixora* and *Vitis*
Katangi	...	8	....
Shahagad	...	9	'Sejo'
Nepanagar	...	12	'Sins', 'Sirati' 'Moheb' and 'Dhaber'

Height:—It has been observed that the trees are shrubby at Wavell Road and Narbada Ravines under the intense biotic influence. Here the average height varies from 10 feet to 25 feet. At Katangi it is upto 30 feet; while at Shahagad and Nepanagar the height varies between 40 to 50 feet.

(b) *Quantitative characters*:—The data is presented in table 2.

Abundance (A), frequency (F) and cover (C) have been studied under these characters.

Abundance:—From table 2 it is seen that the value of abundance per quadrat ranges from 1 to 10 8. In average one tree occurs per quadrat at Shahagad and 10·8 at Wavell Road–a shrubby forest.

Frequency:—In all the forest examined the species show 100% frequency. This indicates the importance of this species in the miscelleneous forests of Madhya Pradesh.

Cover:—Cover percentage ranges from 19 to 40 per quadrat. The lowest value has been observed at Wavell Road while the maximum coverage is noticed at Katangi.

From table 2 it is seen that at Shahagad average coverage is 33% as compared to that of Wavell Road where it is 19%. But the abundance—(number of plants per quadrat) is quite large being 10·8 as compared to only one at Shahagad, Polygraphs confirm the above observation (fig. 1)

TABLE 2—*Average Abundance (A), Frequ.ncy (F) and Cover (C) of the different species in miscellaneous forests of Madhya Pradesh*

Name of species	Wavell Road			Narbada Ravines			Katangi			Shahagad			Nepanagar		
	A	F	C	A	F	C	A	F	C	A	F	C	A	F	C
Anogeissus latifolia ...	10·8	100	19·0	3·1	100·0	19·2	6·8	100	40·0	1·0	100	33·0	2·40	100·0	35·00
Terminalia tomentosa	0·6	40	5·0	—	—	—	4·2	100	23·0	0·6	60	8·4	0·14	14·2	4·28
Tectona grandis ...	—	—	—	—	—	—	—	—	—	2·0	80	16·0	0·42	14·2	0·71
Butea monosperma ...	—	—	—	0·7	42·8	2·7	0·8	40	5·0	0·2	20	2·0	—	—	—
Boswellia serrata ...	—	—	—	1·2	40·0	8·0	—	—	—	—	—	—	1·42	71·4	22·8
Diospyros melanoxylon	0·4	20	2·0	—	—	—	0·6	20	1·0	1·6	20	4·0	0·71	55·5	5·00
Zizyphus sp. ...	1·2	60	5·2	0·1	14·2	0·7	1·0	40	1·4	0·6	20	1·0	—	—	—
Semicarpus anacardium	1·2	40	2·0	—	—	—	—	—	—	—	—	—	—	—	—
S. xylopyra ...	0·2	40	0·4	—	—	—	—	—	—	—	—	—	—	—	—
Lagerstroemia parviflora	4·4	80	7·2	—	—	—	—	—	—	—	—	—	—	—	—
Azadirachta indica ...	0·2	20	2·0	—	—	—	—	—	—	—	—	—	—	—	—
Bauhinia racemosa ...	1·4	80	3·0	0·1	14·2	0·7	—	—	—	—	—	—	—	—	—
Buchanania latifolia ...	1·8	60	9·0	—	—	—	—	—	—	—	—	—	0·57	55·5	7·80
Carissa spinarum ...	4·6	60	5·0	2·7	100·0	4·4	1·0	80	2·0	1·0	80	2·6	0·14	14·2	0·14
Celastrus montana ...	0·4	20	0·4	1·1	42·8	3·5	0·2	20	0·6	0·8	40	4·0	—	—	—
Woodfordia floribunda	—	—	—	1·2	85·7	3·1	—	—	—	—	—	—	—	—	—
Elaeodendron glaucum	0·2	20	0·2	—	—	—	—	—	—	—	—	—	—	—	—
Phyllanthus emblica ...	—	—	—	—	—	—	0·2	20	2·0	—	—	—	—	—	—
Odina wodier ...	0·4	40	1·0	0·2	28·5	0·4	—	—	—	—	—	—	—	—	—
Cassia fistula ...	0·2	20	0·2	0·2	28·5	0·2	—	—	—	—	—	—	—	—	—
Ougeinia dalbergioides	1·4	60	8·4	—	—	—	—	—	—	—	—	—	—	—	—
Mimosa rubicaulis ...	1·0	60	1·4	—	—	—	—	—	—	—	—	—	—	—	—
Ixora sp. ...	—	—	—	0·1	14·2	0·1	—	—	—	—	—	—	—	—	—
Nyctanthes arbor-tristis	—	—	—	0·1	14·2	0·7	—	—	—	—	—	—	—	—	—
Acacia catechu ...	—	—	—	0·2	28·5	2·1	—	—	—	—	—	—	0·14	14·2	1·42
A. leucoplaea ...	—	—	—	0·4	42·8	4·4	—	—	—	—	—	—	—	—	—
Kydia calycina ...	0·4	40	4·0	—	—	—	—	—	—	—	—	—	—	—	—
'Sejo' ...	—	—	—	—	—	—	—	—	—	0·2	20	1·0	—	—	—
'Sinas' ...	—	—	—	—	—	—	—	—	—	—	—	—	0·42	14·2	4·28
'Sirati' ...	—	—	—	—	—	—	—	—	—	—	—	—	0·14	14·2	0·14
'Dhaber' ...	—	—	—	—	—	—	—	—	—	—	—	—	0·14	14·2	2·14
Moheb' ...	—	—	—	—	—	—	—	—	—	—	—	—	0·14	14·2	4·28

Range of variation in the amounts of A, F and C of some important species in the miscelleneous forests examined is compared in table 3.

TABLE 3

Range of Variation in A, F & C of Important Species in Miscelleneous Forests of Madhya Pradesh.

A-abundance; F-frequency; C- % cover.

Name of species		A	F	C
Anogeissus latifolia	...	1 to 10·8	100	19 to 40
Terminalia tomentosa	...	0·1 to 4·2	14·2 to 100	4·2 to 23
Carissa spinarum	...	0·1 to 4·6	14·2 to 80	0·1 to 5
Celastrus montana	...	0·2 to 1·1	20 to 42	0 4. to 4
Butea Monosperma	...	0·2 to 0·8	20 to 42	0·2 to 5
Diospyros melanoxylon	...	0·4 to 1·6	20 to 55	1·0 to 5
Zizyphus sp.	...	0·1 to 1·2	14·2 to 60	0·7 to 5·2

Desity diagram of these forests are presented in fig. 2 From these diagrams it is noted that the forests of Wavell Road, Narbada Ravines and Katangi are homogeneous only to a certain extent. These forests are comparatively young and open to grazing. Shahagad and Nepanagar forests are comparativly heterogeneous ones due to growth of sporadic species.

(II) *Synthetic characters:*—Only constance has been determined under this character.

Constance values of *Anogeissus latifolia,* and *Carissa spinarum* has been found to be 5. *Zizyphus* sp., *Celastrus montana* and *Diospyros melanoxylon* have got 4 constance value. *Butea monosperma* has 3 while *Odina wodier, Bauhinia racemosa* and *Cassia fistula* have 2 constance value. Other important species haveing low constance are *Boswellia serrata, Kydia calycina, Ougeinia dalbergioides* and *Elaeodendron glaucum.*

(*B*) *Teak forests:*—

(*I*) *Analytical characters:*—

(*a*) *Qualitative characters:*—

Associates:—In all 19 species are found in these forests. At Patharia total number of species is 18 while at Badwani it is only 8. *Terminalia tomentosa, Tectona grandis, Butea monosperma* are found to be the constance associates of *Anogeissus latifolia* in these forests.

Some of the species are restricted to only one region. Thus 'Adhmi' and 'Asto' are found at Patharia out of the two forests studied.

Height:– In these forests the tree has good growth and the average height varies from 30 to 40 feet.

(b) *Quantitative characters*:—The values of A, F and C of different species are presented in table 4.

TABLE 4

Abundance (A), frequency (F) and cover (C) of diffrent species in some Teak forests of Madhya Pradesh

Name of species		Patharia			Badwani		
		A	F	C	A	F	C
Anogeissus latifolia	...	10·4	100·0	41·0	2·0	80	14·0
Tectona grandis	...	2·1	87·5	22·0	6·8	100	54·0
Terminalia tomentosa	...	1·1	50·0	4·0	1·2	80	8·0
Butea monosperma	...	0·3	25·0	3·8	1·2	60	3·4
Carissa spinarum	...	0·1	12·5	0·1	0·2	40	5·0
Zizyphus sp.	...	0·2	28·0	0·6	0·2	20	3·0
Diospyros melanoxylon	...	2·6	62·5	7·7	1·2	60	1·0
Madhuca latifolia	...	...	...	...	0·8	60	1·0
Cassia fistula	...	0·1	12·5	1·2	...	...	...
Pterocarpus marsupium	...	0·1	12·5	2·5	...	...	...
Acacia catechu	...	0·1	12·5	0·1	...	...	...
Buchanania latifolia	...	0·1	12·5	0·2	...	...	...
Saccopetalum tomentosum	...	0·7	37·5	2·8	...	...	...
Bridellia retusa	...	0·2	25·0	1·0	...	...	...
Anthocephalos cardifolia	...	0·2	25·0	1·1	...	...	...
Lannea grandis	...	0·2	12·5	1·2	...	...	...
'Asto'	...	0·1	12·5	0·6	...	...	...
'Adhmi'	...	0·1	12·5	0·6	...	...	...
'Kheja'	...	0·1	12·5	0·6	...	...	...

Polygraphs (Fig. 3) further confirm these observations. Density diagrams (*cf.* fig. 4) show that the Patharia forest is less homogeneous than that of Badwani.

(II) *Synthetic characters* :—Along with *Anogeissus latifolia, Terminalia tomentosa, Butea monosperma* and *Tectona grandis* have been observed to have 5 constance value. Rest of the species have low constance values,

(C) *Sal forests:—*

(I) *Analytical characters:—*

(a) *Qualitative characters:—*

Associates :—In all 24 species have been found in these forests. The most important ones are *Shorea robusta, Terminalia tomentosa, Madhuca latifolia* and *Anogeissus latifolia.*

Height:—Here the average height is between 40 and 60 feet.

In all these forests *Anogeissus latifolia* is very thinly populated.

(b) *Quantitative characters*:-These are presented in table 5. From the table it is seen that abundance values range from 0·12 to 4·00. The lowest frequency (13%) has been found at S. Raipur while maximum of 60% is at Pachmari. The average area occupied by species in each quadrat is as low as 1·8% at S. Raipur while at Pachmari it is as much as 19%.

TABLE 5

Average values of abundance (A), frequency (F) and cover (C) of different species in Sal forests of Madhya Pradesh

Name of species	Pachmari			N. Baster			Mandla			S. Raipur		
	A	F	C	A	F	C	A	F	C	A	F	C
Anogeissus latifolia	1·6	60	19·0	4·0	40	5·0	0·16	16	5·0	0·12	13	1·80
Shorea robusta	2·8	60	26·0	3·6	100	83·0	2·30	100	43·0	2·50	100	74·70
Terminalia tomentosa	0·2	20	4·0	0·2	20	12·0	0·16	32	5·0	0·43	31	10·90
Madhuca latifolia	0·4	20	1·4	0·2	20	5·0	0·16	16		0·16	6	0·62
Diospyros melanoxylon	0·8	20	1·0	0·2	20	2·0	...	...	...	0·12	13	0·32
Buchanania latifolia	1·0	80	8·4	0·2	20	2·0	...	...	...	0·06	6	0·60
Phyllanthus emblica	...	...	...	...	...	...	...	...	...	0·16	16	0·38
Odina wodier	...	...	...	...	...	...	0·16	16	0·3	...	...	...
Semicarpus anacardium	...	...	...	...	...	...	...	...	...	0·06	6	1·25
Bauhinia racemosa	...	...	...	...	...	...	0·66	32	6·6	0·12	6	...
Cassia fistula	...	...	...	...	...	...	...	...	...	0·25	25	2·50
Pterocarpus marsupium	...	...	...	0·2	20	6·0	...	...	...	...	...	...
Kydia calycina	0·2	20	0·4	...	...	...	...	...	...	...	...	...
Tectona grandis	...	...	...	...	...	...	...	...	...	0·37	31	15·3
Eugenia jambolana	...	...	...	...	...	...	...	...	...	0·20	20	8 00
Adina cordifolia	...	...		...	...	...	...	...	...	0·06	6	0·33
'Bahera'	0·4	20	6·0	...	...	...	...	...	...	...	...	...
Embellia robusta	...	...	...	...	...	...	0·16	16	...	...	...	...
'Roli'	...	...	...	...	...	...	...	...	...	0·20	20	2 00
'Doomer'	...	...	...	...	...	..	0·06	6	0·66	...	...	...
Corthamus tinctorius	...	...	...	...	...	...	...	...	...	0·12	13	0·66
'Khusia'	...	...	...	...	...	...	0·16	16	...	...	...	...
Cleisthanthus sp.	...	...	...	...	...	...	...	...	...	0·6	6	...
'Dhankot'	...	...	...	...	...	...	0·16	16	...	...	...	...

From the above table it is clear that *Anogeissus latifolia* is very thinly populated at S. Raipur. Among the Sal forests studied, only at Pachmari it has better distribution. Density diagrams reveal that except for Pachmari rest of the forests are homogeneous to a certain extent.

(II) Synthetic characters :—*Shorea robusta, Terminalia tomentosa, Madhuca latifolia* and *Anogeissus latifolia* show 5 constance value. *Diospyros melanoxylon, Buchanania latifolia* have 4 while *Phyllanthus emblica, Odina wodier* have only 2 constance values.

DISCUSSION AND INTERPRETATION OF RESULTS

(1) Analytical characters :—

(a) *Quantitative characters* :—Refering to tables 2, 4 and 5 it is noted that the range of variation in 'abundance' in miscelleneous forests is from 1 to 10·8, in Teak forests 2 to 10·8 and in Sal forests it is 0·12 to 4·00. Thus in 'Sal' forests the number of trees per quadrat is very less while it is higher in miscelleneous and Teak forests.

Miscelleneous and Teak forests have 80% to 100% frequency showing it's constant occurrence in these forests. But in Sal forests it is between 13% and 60% showing its sparse distribution.

In miscelleneous forests the range of variation in cover is from 19% to 40%, in Teak forests it is from 14% to 40% but in Sal forests it is only 1·8% to 19%. Thus in miscelleneous and Teak forests it occupies larger area in comparison to Sal forests. A comparison between A, F and C of *Anogeissus latifolia* in the 3 types of forests examined is given below :

Miscelleneous forests			Teak forests			Sal forests		
A	F	C	A	F	C	A	F	C
1-10·8	100	19-40	2-10·8	80-100	14-40	0·12-4	13-60	1·8-19

(b) *Qualitative characters* :—

Associates :—In all more than 50 species are found to be associated with this tree. Out of these only *Terminalia tomentosa* is found in all types of forests. *Diospyros melanoxylon* and *Buchanania latifolia* occur almost regularly in all forests. The other important species are *Butea manosperam, Carissa spinarm, Celastrus montana Tectona grandis, Shorea robusta* and *Madhuca latifolia.*

It has also been observed that some low species like *Carissa spinarum, Celastrus montana, Zizyphus sp.*, are found in miscelleneous and some Teak forests only. These are absent in all the Sal forests examined.

Anogeissus latifolia has never been found to occur in aggregates. The trees are always hypodispersed and show a low sociability value. The tree usually forms the first canopy irrespective of the type of forests.

In miscelleneous forests the tree has poor growth and the average height varies between 10 to 20 feet. In Sal and Teak forests it has good growth and the average height is 40 to 50 feet.

TABLE 6

Synthetic Characters (Constance & Fidelity—0 to 5 Scales) of Madhya Pradesh Forests

Name of species	Constance in Scale of 0 to 5											
	Wavell Road	Narbada Ravines	Katangi	Shahagad	Nepanagar	Patharia	Badwani	Pachmari	N. Bastar	S. Raipur	Mandla	Fidelity
Anogeissus latifolia	5	5	5	5	5	5	4	3	2	1	1	1
Terminalia tomentosa	2	...	5	3	1	2	4	1	1	2	2	1
Tectona grandis	...	...	...	4	1	4	5	--	...	2	...	4
Lagerstroemia parviflora	4	...	...	...	...	...	...	...	...	...	...	5
Carissa spinarum	3	5	4	4	1	1	2	...	..	...	...	3
Boswellia serrata	...	1	...	...	4	...	...	...	...	...	...	5
Zizyphus sp.	3	1	2	1	...	1	1	...	...	...	...	3
Shorea robusta	...	...	...	...	...	...	...	...	5	5	5	4
Semicarpus anacardium	2	...	...	...	...	...	...	5	...	1	...	5
,, Xylopyra	2	...	...	...	...	...	...	...	...	...	...	5
Celastrus montana	1	4	1	2	...	...	...	...	...	...	...	4
Butea monosperma	...	2	2	1	...	1	3	...	...	...	...	4
Woodfordia floribunda	...	4	...	...	...	...	...	...	...	...	...	5
Elaeodendron glaucum	1	...	...	...	...	...	...	...	...	...	...	5
Phyllanthus emblica	...	...	1	...	...	...	...	...	...	...	1	5
Odina wodier	2	1	...	...	...	...	...	...	...	...	1	4
Diospyros melanoxylon	1	...	1	...	...	2	3	..	1	1	...	3
Madhuca latifolia	...	...	...	1	3	...	3	1	1	1	1	3
Flaucortia sp.	3	...	...	...	...	...	...	1	...	...	...	5
Bauhinia racemosa	4	1	...	...	...	...	...	...	...	1	1	4
Cassia fistula	1	1	...	...	...	1	...	...	...	2	...	4
Pterocarpus marsupium	...	...	...	...	...	1	...	...	1	...	...	5
Ougeinia dalbergioides	3	...	...	...	...	...	...	1	...	...	...	5
Mimosa rubicaulis	3	...	...	...	...	...	...	...	...	1	...	5
Ixora sp.	...	1	...	...	...	...	...	...	...	...	...	5
Nyctanthes arbor-tristis	...	1	...	...	...	...	...	...	...	...	...	5
Acacia catechu	...	1	...	...	1	1	...	...	...	...	...	4
,, leucophlaea	...	2	...	...	...	...	...	...	...	...	...	5
Kydia calacina	2	...	...	...	...	...	...	...	...	...	...	5
Buchanania latifolia	3	...	1	...	3	1	—	...	...	1	...	3
Saccopetalum tomentosum	...	...	...	...	...	1	...	4	1	1	...	5
Bridellia retusa	...	...	...	...	...	1	...	...	...	...	...	5
Anthocephalus cordifolia	...	...	...	...	...	1	...	...	...	...	...	5
Lannea grandis	...	...	...	...	...	1	...	...	...	...	...	5
Eugenia jambolana	...	...	...	...	...	...	...	...	...	2	2	4
Adina cordifolia	...	...	...	...	...	...	...	...	...	1	...	5
Corthamus tinctorius	...	...	...	...	...	...	...	...	...	1	...	5
Embelia robusta	...	...	...	...	...	...	...	...	...	...	1	5
'Sinas'	...	...	...	...	1	...	...	...	...	...	---	5
'Sirati'	...	...	...	...	1	...	...	...	...	...	...	5
'Dhaber'	...	...	...	...	1	...	...	...	...	...	...	5
'Moheb'	...	...	...	...	1	...	...	...	...	...	...	5
'Sejo'	...	...	...	1	...	...	...	...	...	...	...	5
'Asto'	...	...	...	...	...	1	...	...	...	...	...	5
'Athami'	...	...	...	...	...	1	...	...	...	...	...	5
'Kheja'	...	...	...	...	...	1	...	...	...	...	...	5
'Bahera'	...	...	...	...	...	...	...	1	...	...	...	5
'Roli'	...	...	...	...	...	...	...	1	...	...	...	5
'Doomer'	...	...	...	...	...	...	...	...	1	...	...	5

II. *Synthetic characters:—Terminalia tomentosa* is constantly present in all the forests examined. However, the constance value of *Terminalia tomentosa* fluctuates. The other species which is almost constantly present in all the forests studied is *Diospyros melanoxylon.* The constance value of this species also varies. The constance and fidelity are given in table 6.

A study of 'fidelity' figures of *Anogeissus latifolia, Tectona grandis, Diospyros melanoxylon* and *Shorea robusta* reveal that Sal and Teak are the species having high fidelity values and thus have low ecological amplitude. *Anogeissus latifolia Terminalia tomentosa* and *Diospyros melanoxylon* are 'companions' in all the forests examined. Of these *Terminalia tomentosa* and *Diospyros melanoxylon* have comparatively low cover.

From the foregoing phytosocialogical characters it is seen that *Anogeissus latifolia* is distributed throughout Madhya Pradesh and in all types of forests. It appears to dominate to a certain extent only in miscellaneous forests but occurs quite frequently in Sal and Teak zones of this state as well.

From the study of fidelity it has been revealed that the above mentioned widespread occurrence of *Anogeissus latifolia* can be explained on the basis of it's high ecological amplitude. *Anogeissus latifolia* has a low fidelity value and thus has a high ecological amplitude. Its pattern of distribution further shows that probably *Anogeissus latifolia* tolerates a large variation in different factors of soil and climate; and at the same time it can successfully stand biological operations like grazing. In such areas it acquires a shrubby habit.

Apart from these observations it can also be noted that it is not a sociable species, never makes a pure stand of its own and never completely dominates forests, as Sal and Teak do.

Further a peculiar status of *Anogeissus latifolia* is observed. This species appears to be a transitional one. On one hand it appears to take over from such low species as *Carissa spinarum. Celastrus montana, Zizyphus* sp., and on the other hand it probably merges into dense climatic climax forests of Sal and Teak. The same is schematised below:—

OPEN SCRUBBY FORESTS

(*Celastrus montana, Carissa spinarum, Zizyphus sp., Butea monosperma*)

AND *Anogeissus latifolia.*

⇅

MIXED FORESTS

(*Anogeissus latifolia, Buchanania latifolia, Terminalia tomentosa*)

⇅	⇅
Sal, *Anogeissus latifolia*	Teak, *Anogeissus latifolia*
or	and
Sal, Bamboo, *Anogeissus latifolia*	*Terminalia tomentosa*
⇅	⇅
'Pure Sal'	'Pure Teak'

SUMMARY

1. *Anogeissus latifolia* Wall. is distributed throughout India except Assam and Bengal. Outside India it occurs only in Ceylon.

2. An attempt has been made to study phytosociological characters of this tree in Madhya Pradesh Both analytical and synthatic characters have been examined.

3. For the purpose of comparison, three types of forests have been studied, viz., Miscellaneous, Teak and Sal forests.

4. The value of abundance, frequency and cover of this species in miscelleneous and Teak forests are higher than those of Sal forests. In Sal forests it has sparse distribution.

5. In all 50 species are found associated with *Anogeissus latifolia. Terminalia tomentosa* is a constant companion.

6. It has poor growth in the open scrubby miscelleneous forests. Here the average height varies between 10 to 20 feet. But in other forests the tree has healthy growth and the height is between 40 and 50 feet.

7. *Anogeissus latifolia* has low fidelity value and thus has high ecological amplitude. Its widespread distribution can be explained on this basis.

8. *Anogeissus latifolia* has never been found in aggregates and thus has low sociability value.

9. The status of *Anogeissus latifolia* in succession is observed. This species appears to take over from such low species as *Carissa spinarum Celastrus montana, Zizyphus* sp. and on the other hand it probably merges into dense climatic climax forest of Sal and Teak.

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LITERATURE CITED

1.	Braun Blanquet, J.,	1932	Plant Sociology. Translated by Fuller, G. D. and Conard, H. S., McGrow Hill Book Co., Inc. New York and London.
2.	Chaturvedi, B.,	1947	Indian Forester 73, p. 544.
3.	Chourey, S.,	1953	A study of the reproductive capacity of six dominant forests trees. M.Sc. Thesis, Saugar University.
4.	Desai, A. K.,	1908	Indian Forester. 34, p. 15.
5.	Hanson, H. C.	1950	Ecology of grasslands. Bot. Rev. 16:6.
6.	Jagdamba Prasad,	1943	Indian Forester. 69:5.
7.	Misra, R.,	1956	The Vegetation of Amar Kantak. Bull. bot. Soc. Saugar Univ. 8:1-2.
8.	Misra, R., & G. S. Puri	1957	Indian Manual of Plant Ecology. The English Book Depot. Poona 1.
9.	Oosting. H. J.	1848	A study of Plant Communities. W. H. Freeman & Co., California.
10.	Pandeya, S. C.,	1953	Ecological studies of grasslands of Saugar. Ph. D. Thesis Saugar University.
11.	Pearson, R. S.,	1908	Indian Forester. 33. p. 231.
12.	Rao, H. S.	1934	Indian Forester. LX 2 p. 150—153.
13.	Raunkiaer, C.,	1934	The life forms of plants and statistical plant geography, being collected papers of C. Raunkiaer.
14.	Tireman, H.,	1906	Indian Forester. 32, p. 390.
15.	Troup, R. S.,	1921	Silviculture of Indian trees, 2., Oxford.

COMPOSITION OF SOME SAL (*SHOREA ROBUSTA* GAERTN.) FORESTS OF MADHYA PRADESH

By

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INTRODUCTION

An ecological study of forests like any other unit of vegetation comprises composition of plant community and the dynamics of its causal interrelations with the existing environment. The knowledge of analytic and synthetic characters of plant society termed as plant sociology, throws light on the behaviour of different factors which control development and distribution of a plant community. It is with these aims that Sal (*Shorea robusta* Gaertn) forests of Madhya Pradesh have been analysed.

Sal has been recognised as one of the major timber trees of Indian forests. The tree is characterized by gregarious habit, straight stem which bears few branches and crown of leaves, the presence of conspicuous deep longitudinal furrows in the bark and numerous small whittish flowers which produce winged fruits. Sal forests occupy almost a continuous strip from Kangra district of Punjab to Darrang district of Assam (Troup, 1921). In central India it occurs in Santal pargana, Chhota Nagpur, Orissa and Madhya Pradesh. The distribution of Sal has been also reported in Ganjam district of Madras.

As far as the author is aware there is no work as yet on the phytosociology of Sal forests of Madhya Pradesh. In Madhya Pradesh the previous Sal studies pertain mainly to distributional extent, geology and soil requirements. Thus, Bose (1883-84) observed that rocks of south Raipur Sal forests are mainly gneisses, sandstone and quartzites. In his notable work on the silviculture of Indian trees, Troup (1921) gave a detailed account of Sal distribution in Madhya Pradesh Maitland (1924) classified different Sal forests of Madhya Pradesh on the basis of their height. Champion (1933) studied types of Sal forests and their geology. Mooney (1947) observed that Sal occurs mainly on acidic soils, which disappears when such top soils are washed off. Sathe (1951) has made an attempt to correlate geology and type of Sal forests. Hewetson (1953) and Khan (1953) discussed exploratory trends in Sal forests of this state. Puri (1954) described the pattern of Sal distribution in Madhya Pradesh in the form of a "sign of interrogation". He further pointed out that Sal is a "calcifuge" species growing mostly on non-calcareous and base deficient soils.

In Madhya Pradesh, Sal forests are occupying the eastern part of the state since prehistoric era. With the advent of human population and civilisation severe biotic operations resulted into thinking of the primarily dense forests of Madhya Pradesh hence, "very little of primeval forests are left now"—Misra (1957). Such biotic disturbances have greatly influenced the entire Indian forests hence they have been classed in "bio-edaphic" series of succession by Misra and Puri (1957). Moreover, many of the Sal forests in Madhya Pradesh are copious forests.

The paper deals with the distribution of Sal and its associates as they stand today in the localised Sal regions of the state. This may give basis for further investigations on the ecology of Sal.

METHOD OF STUDY

The forests have been studied by random quadrats and belt transects (20' wide, which runs across the contours). The size of the quadrat 20' ×20' has been arrived at by species area curve, after Oosting (1948). The following phytosociological characters have been studied :—

1. Analytic Characters—

(*a*) Quantitative characters—

(*i*) Abundance (*ii*) Frequency (*iii*) Cover.

(*b*) Qualitative characters—

(*i*) Associates (*ii*) Sociability (*iii*) Stratification, and

(*iv*) Height of the trees.

2. Synthetic Characters—Constance.

The climate and geology of the different forests have already been given by Hewetson (1953) and Khan (1953) and will not be given here.

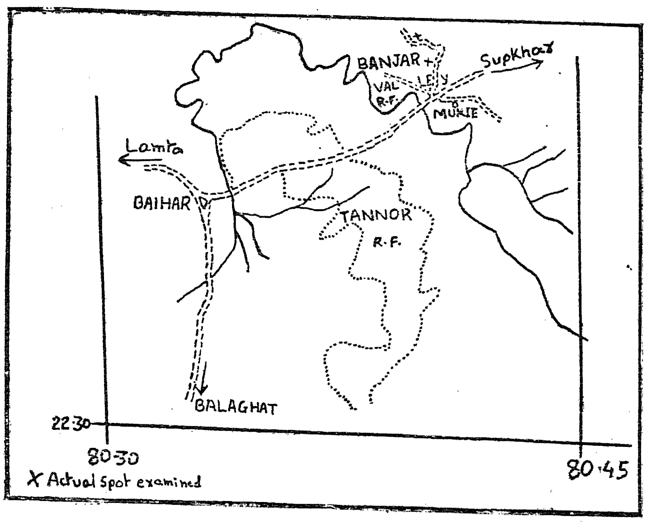
The divisions under study are Balaghat (Mukie), Hoshangabad (Pachmarhi), Bilaspur and North Bilaspur (Lormi and Baikuntpur), North Bastar (Tiria forests), South Raipur (Nagri and Risgan range) and Mandla (Aamer and Baikuntpur). It may be mentioned here that out of six divisions examined, N. Bilaspur (Baikuntpur) have sparse growth of Sal otherwise in the remaining forests Sal dominates the area.

PRESENTATION OF PHYTOSOCIOLOGICAL CHARACTERS

In the following pages phytosociological characters of the different forests examined, will be described division wise.

1. Balaghat Division (Mukie forests)—

Mukie (*cf*. Map. 1) Sal has been classed to belong to quality II by Maitland (1924). The trees are 71 to 80 feet tall and are quite gregarious.



Map 1. Mukie (Balaghat Division)

The underlying rocks are gneisses.

In all 7 tree species have been observed in the forests. Of these the important associates of Sal are *Terminalia tomentosa*, *Buchanania latifolia* and *Careya arborea*. The other species are *Pterocarpus marsupium*, *Mudhuca latifolia* and *Phyllanthus emblica*. Only *Terminalia tomentosa* goes upto the height of Sal, others belong to second layer. The third layer of the ground flora although sparse is occupied by Sal saplings and grasses like *Oplismenus* and *Imperata* species, apart from the minor annual forbs.

The quantitative characters of the forests are presented in table 1.

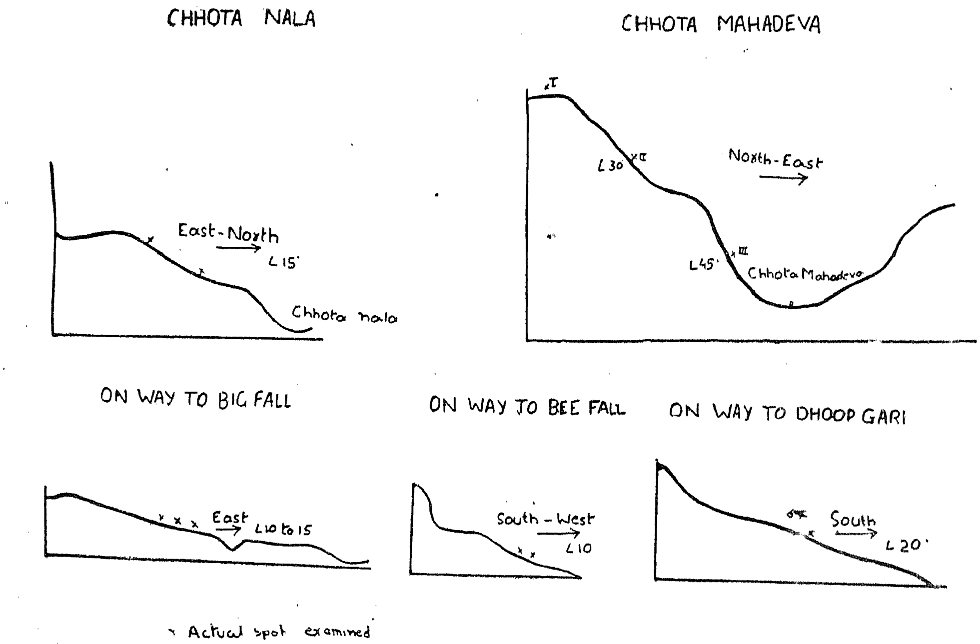
From table 1 it is observed that Sal occurs with 100 per cent frequency. On an average 6·13 number of Sal trees occur in each quadrat (table 7). The number of Sal saplings is 9·1 per quadrat. The Sal trees cover on an average 86 per cent of the ground per quadrat.

In open spots in the forests a number of grasses dominate. In such open spots Sal saplings were not frequently found. The dominate grasses are *Imperata cylindrica*, *Heteropogon contortous*, *Eragrostis uniloides*, *Arundinella* sp., *Themeda* sp., and *Ophiurus* sp., Generally such spots are depressions which remain boggy upto November and December. On the margins *Drosera* was observed.

Constance values of the different species are given in table 8 and will be discussed later.

Homogeneity of the forests has been studied after Pandeya (1953). The The density diagram drawn for Mukie (fig. 1) shows that the forests are homogenous to a great degree and can be classed as "hypodispersed".

2. Hoshangabad Division (Pachmari forests)—



Map 2. Pachmarhi (Hosangabad Division) showing diagrammatic topography of the localities examined.

Pachmarhi (Map. 2) forests represent poor quality of Sal. They have been assigned to class III and IV quality of Sal forests (*cf.* Maitland, 1924). An average Sal tree attains the height of 35 to 50 feet here.

TABLE 1

Quantitative characters of MUKIE (Balaghat Division) forests.

LOCALITY : Near forest campus (Goerilla road) SLOPE : Almost plain

FACE OF SLOPE : ×

GEOLOGY : Gneisses. DATED : 13-10-1956.

(*N. B.*—By belt transect and random samples)

Transect No. 1 from forest road to east-west direction quadrat + 20′ interval

Number	Species	Belt transect 1 A	1 C	2 A	2 C	3 A	3 C	4 A	4 C	Frequency	Random sampling 1 A	1 C	2 A	2 C	Frequency
1	*Shorea robusta*	5 (8±)*	30	7	60	3 (13±)	60	1 (14±)	95	100	13 (10±)	100	8 (10±)	95	100
	Average height of trees	40′		60′		70′		90′			80′		90′		
2	*Terminalia tomentosa*	6	30	7	30	3	15	...	...	75	1	2	...	...	64
3	*Phyllanthus emblica*	...	...	...	...	...	...	...	...	×	1	2	...	...	16
4	*Pterocarpus marsupium*	(1±)		...	...	...	...	...	...	25	...	...	...	...	16
5	*Madhuca latifolia*	...	...	...	...	...	...	1	1	25	...	...	...	...	16
6	*Buchanania latifolia*	(2±)		...	...	...	...	(1±)		50	...	...	...	...	33
7	*Careya arborea*	...	...	...	...	1	10	1	1	50	...	...	...	...	33
	Degree of slope ...	±		±		±		±			±		±		
	Degree of boulders (Scale—0 to 5)	±		±		±		±			±		±		
	Degree of litters (Scale—0 to 5)	1		2		3		3			±		±		

*Figures indicate number of saplings (±).

The geological formation of Pachmarhi plateau is upper Gondwana. The conglomerated rocks of the region are generally exposed showing embedded pebbles bearing thin mantle of soil. However, Sal forested areas have thicker soils having rocks exposed here and there.

Total number of tree species in the forests examined were 9. Common associates of Sal are, *Buchanania latifolia, Terminalia tomentosa, Diospyros melanoxylon, Madhuca latifolia* and *Terminalia chebula.* With less frequency Sal occurs in association with *Anogeissus latifolia, Pterocarpus marsupium* and *Saccopetalum tomentosum.* Most of the tree species are observed to reach the height of Sal. Ground flora is poor represented by saplings of Sal and grasses like *Apluda mutica, Cymbopogon martini, Heterropogon contortus, Iseilema* sp. & *Themeda* sp.

In table 2 are presented the quantitative characters of the Sal forests of Pachmarhi. The observations show that on an average 6·22 trees of Sal covering 66·66 per cent of the area are distributed in each quadrat. In these forests Sal occurs with 100 per cent frequency yet regeneration is poor, showing only 0·88 number of Sal sapling in each quadrat (table 7).

A small patch of Sal trees have been observed at "Chhota nala". Here average tree is 25 feet tall and nearly 40 feet apart from each other. Similar stands of Sal have been observed on way to Chhota Mahadeva and Big fall.

Apart from grasses observed in Mukie forests a number of other plants contribute to the ground flora here. Notable amongst them are a few ferns.

Sal leaf litter is also spread on the ground with good coverage. Fair regeneration of Sal has been observed in these forests specially along the streams. Sal is absent at higher and lower altitude on the hills on way to "Chhota nala", "Chhota Mahadeva", "Big fall", "Dhoop garh" and "Bee fall".

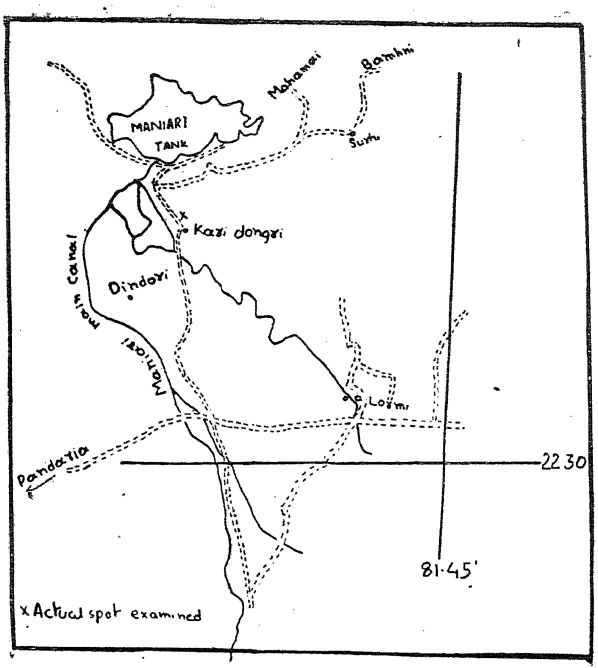
The density diagram (fig. 1) show that the forests are homogeneous and "hypodispersed".

3. North Bilaspur & Bilaspur Division (Baikuntpur & Lormi forests.)

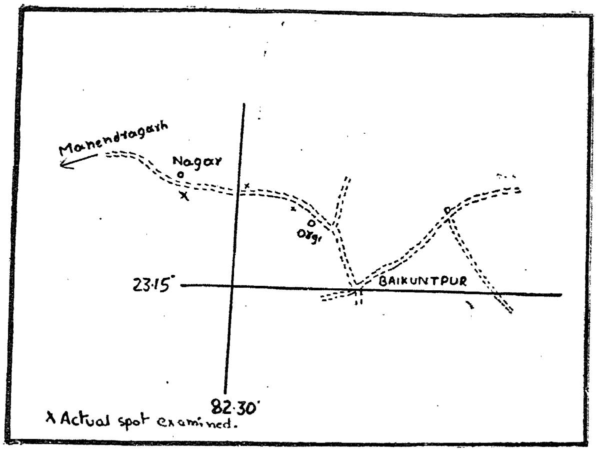
The observed forests of Bilaspur division are mixed type of Sal forests. The usual height of Sal tree ranges between 61 and 70 feet.

The forests of Lormi range [Map 3 (*a*)] have dark black alluvial soil intermingled with mica particles whereas Baikuntpur [Map 3 (*b*)] forests have Archean rocks to support them.

Along Sal, nine other species have been observed to grow in these forests. The Sal forests are present in patches. The associates noted in the random quadrats are 'Sandhu', *Buchanania latifolia Pterocarpus marsupium, Bauhinia racemosa, Cleistanthus collinus, Butea monosperma, Ficus religiosa,* 'Roli' and 'Gonicya' (table 3a & b). The other tree species which are not observed in the quadrats but common in the neighbouring areas are:—*Terminalia tomentosa, Terminalia bellerica, Termlnalia chebula, Phyllanthus emblica, Madhuca latifolia* and *Diospyros melanoxylon.* Thus, in open forests of Baikuntpur the above tree species although not associated with Sal form a major portion of the forest vegetation.



Map 3 (*a*) Lormi range (Bilaspur Division).



Map 3 (*b*) Baikuntpur (N. Bilaspur).

TABLE 2

Quantitative characters of Pachmarhi (Hosh.ngabad forests).

LOCALITY : Around Pachmarhi town — SLOPE : ×

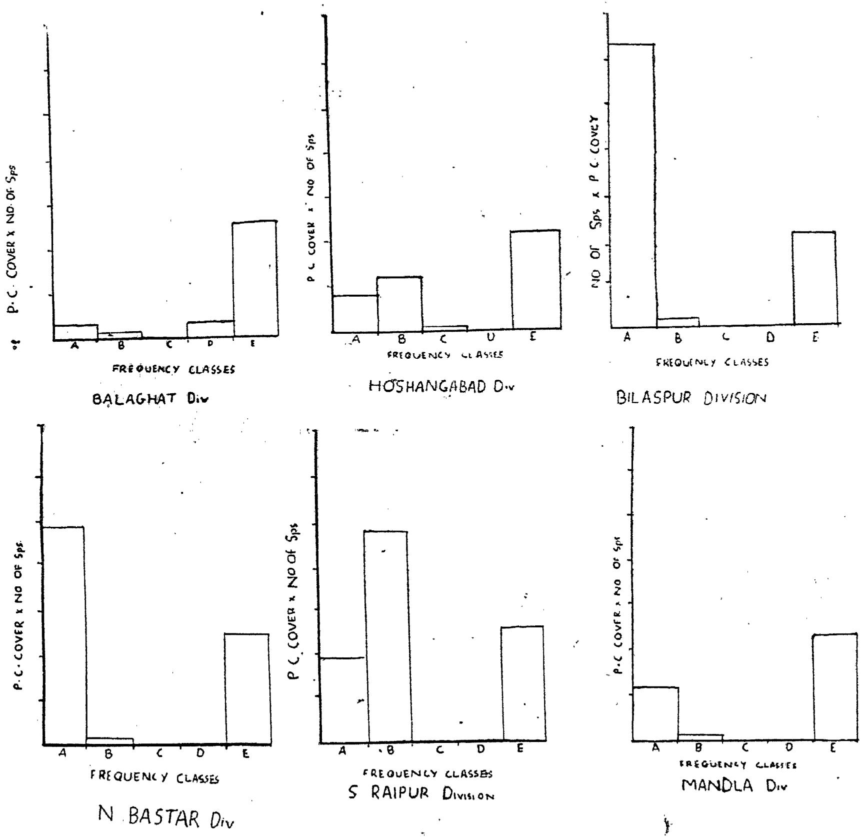
GEOLOGY : Upper Gondwana (Sandstone) — FACE OF SLOPE : ×

DATED : 5th to 8th Jan., 1957.

(*N. B.*—By random samples)

Number	Species	Chhota nala (East-north)		Choota Mahadeva (West-north) 1		2		3		Big fall (East-south) 1		2		3		Dhoop garh (South-west)		Bee fall (West)		Frequency in p. c.
		A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
1	*Shorea robusta*	8	90	3	70	8	80	12	90 (6±)	(2±)*		3	70	6	70	6	50	10	80	100
	Average height of trees		50'		65'		70'		25'			70'			60'		30'		35'	
2	*Terminalia tomentosa*	1	25	...	...	...	...	1	10	...	...	...	...	...	...	...	...	...	...	22
3	*Saccopetalum tomentosum*	...	...	...	...	...	...	1	5	...	...	...	...	...	...	...	...	...	...	11
4	*Diospyros melanoxylon*	...	...	...	...	(8	±)	...	...	4	5	...	...	...	...	...	...	...	...	22
5	*Anogeissus latifolia*	...	...	...	...	...	...	...	...	5	30	...	...	...	...	...	...	...	...	11
6	*Madhuca latifolia*	...	...	...	...	...	...	...	...	2	7	...	...	...	...	1	20	...	...	22
7	*Buchanania latifolia*	...	...	...	...	...	...	...	...	1	30	2	10	1	5	...	...	1	5	44
8	*Terminalia chebula*	...	...	...	...	...	...	...	...	...	...	2	30	1	5	...	...	...	...	22
9	*Pterocarpus marsupium*	...	...	...	...	...	...	...	...	...	...	...	...	1	2	...	...		...	11
	Degree of slope ...	15		±		30		45		10		10		15		20		10		
	Degree of boulders (Scale 0 to 5)	±		±		1		5		1		2		±		±		+		
	Degree of litters (Scale 0 to 5)	3		±		4		1		±		1		1		1		...		

*Figures indicate number of saplings.



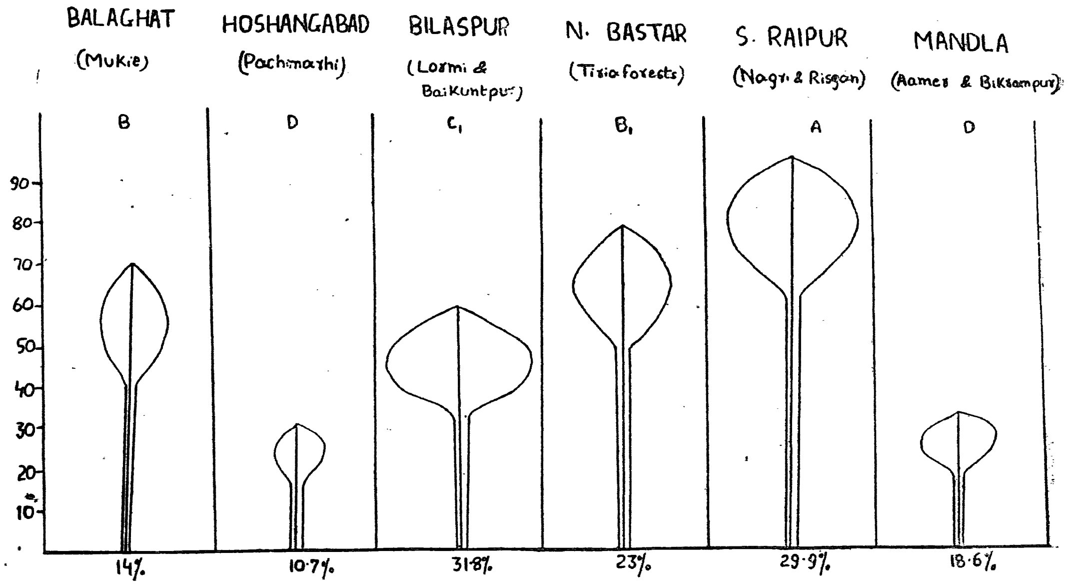
DENSITY DIAGRAMS SHOWING DISTRIBUTION OF SAL FORESTS IN MADHYA PRADESH

FIG. 1

The ground flora under Sal is covered by saplings of Sal and Sal litters. The grasses like *Oplimanus* sp., and *Themeda caudata* are also met with.

In order to study such patchy forests random samling method, as suggested by Finney (1949), Bourdeau (1953) and Shanks (1953), was followed.

The average quantitative characters of Bilaspur division (table 7) shows that Sal occurs with 100 per cent frequency and nearly 60 per cent cover. Number of Sal trees per quadrat works out to 2 whereas figure for saplings of Sal is also 2. Average cover of a Sal tree is 31·8 per cent which is highest value in all the examined forests of Madhya Pradesh (fig. 2).



Average height 91' or more - A
" " 81' to 90' - B1
" " 71' to 80' - B
" " 61' to 70' - C1
" " 51' to 60' - C
" " 35' to 50' - D

RELATIVE HEIGHT AND AVERAGE PERCENTAGE COVER PER QUADRAT OF A SAL TREE IN DIFFERENT FORESTS OF MADHYA PRADESH

Fig. 2

TABLE 3 (*a*)

Quantitative characters of Tiria " Kari dongri " (Lormi, Bilaspur division forests).

LOCALITY : On the bank of Maniari river — SLOPE : Plain.

GEOLOGY : Alluvial, mixture of gneisses and clay schist. — FACE OF SEOPE : ×

DATED : 2·3-'57.

(*N. B.*—By random samples)

No.	Species	Random quadrat 1		Random quadrat 2		Random quadrat 3		Random quadrat 4		Frequency
		A	C	A	C	A	C	A	C	
1	*Shorea robusta* ...	1 (5±)	80	3	55	1	90	3 (3±)	50	100
	Average height of tree	70'		80'		70'		60'		
2	*Cleistanthus collinus*	3	40	...	...	...	...	...	...	25
3	"Gonicya" ...	...	...	1	20	...	...	...	...	25
4	"Roli" ...	...	...	1	20	...	...	...	...	25
5	"Sandhu" ...	...	...	...	...	1	30	3	10	50
6	*Bauhinia racemosa* ...	...	...	...	...	1	20	...	...	25

	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4
Degree of slope ...	±	±	±	±
Degree of boulders ...	±	±	±	±
Degree of litters ...	±	1	1	2

TABLE 3 (*b*)

Quanititative characters of Baikuntpur (North Bilaspur) forests.

LOCALITY : On way to Nagar. SLOPE : Plain

GEOLOGY : FACE OF SLOPE : ×

DATED : 27-2-1957.

(*N. B.*—By random samples.)

No.	Species		Random quadrat 1		Random quadrat 2		Random quadrat 3		Frequency
			A	C	A	C	A	C	
1	*Shorea robusta*	...	3	40	1	40	1 (6±)	50	100
	Average height of tree	...	40'		60'		40'		
2	*Buchanania latifolia*	...	3	20	1	10	...	...	66·6
3	*Buttea monosperma*	...	1	25	...	...	...	...	33·3
4	*Ficus religiosa*	...	...	...	...	...	1	30	33·3
5	*Pterocarpus marsupium*		...	...	1	40	...	...	33·3

Degree of slope ...	...	±	±	±
Degree of boulders	...	±	±	±
Degree of litters ...	...	2	1	2
(Scale—Oto 5)				

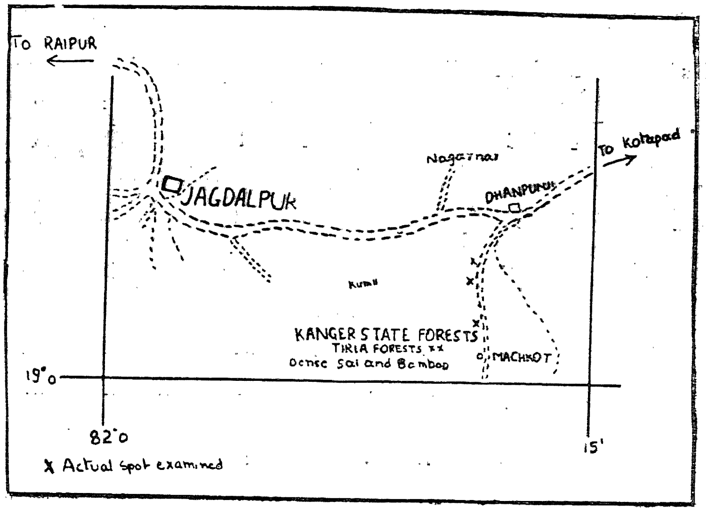
A study of density diagrams (fig. 1) shows that the homogeneity of the forests has been greatly hampered by the appreciable increase in the size of frequency class 'A' which is due mainly to sporadic species.

4. North Bastar (Tiria forest)—

Examined Sal forests of North Baster division (Map. 4) are of Sal quality class I & II (*cf.* Maitland, 1924). Trees are on an average 81 to 90 feet tall growing in close colony and thus they have high sociability value.

The underlying thick mantle of soil which supports the forests has been drived from *cuddapah* rocks.

Sal is found to grow (table 4) frequently with *Anogeissus latifolia, Terminlia tomentosa, Madhuca latifolia, Pterocarpus marsupium, Eugenia jambolana, Diospyros melanoxylon, Buchanania latifolia* and 'Roli'. It has been observed that trees of *Anogeissus latifolia, Terminalia tementosa, Petrocarpus marsupium* and *Engenia jambolana* generally attains the



Map 4. Ti:ia fosests (N. Bastar Division).

height of Sal trees. In these forests at places Sal grows in pure stands. The ground flora under tall canopy is generally scanty and mostly occupied witt litters. However, under young Sal trees, grasses like *Imperata cylindrica, Arundinella* sp., have been noted.

A study of average quantitative characters (table 7) shows that the number of Sal trees per quadrat falls between 3 to 4 ; covering 83 per cent of the ground. On an average 0·6 saplings of Sal have been observed in each quadrat.

Density diagram (fig. 1) shows that due to the preponderance of frequency class 'A' homegeneity of the forests is less.

TABLE 4

Quantitative characters of Tiria (North Bastar Division) forests.

LOCALITY : In the vicinity of Dhan punji and Machkot villages

SLOPE : Almost plain.

GEOLOGY : Archeans

FACE OF SLOPE ×

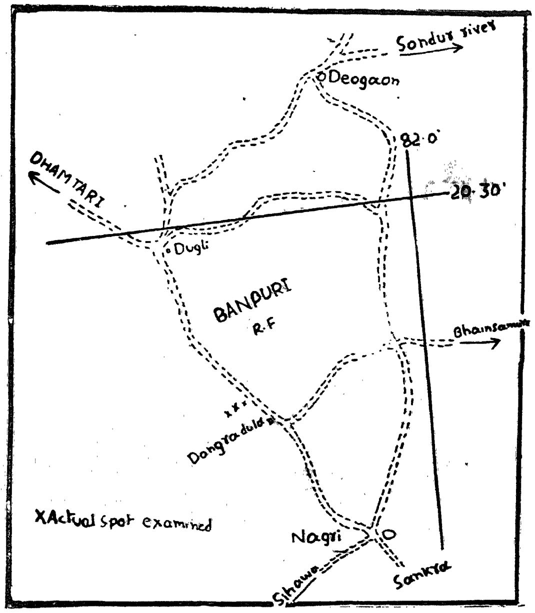
DATED : 8-3-1957.

(*N. B.*—random samples.)

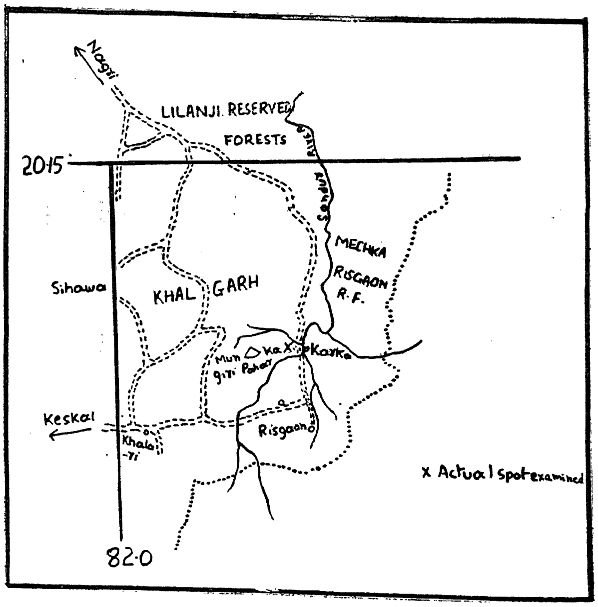
No.	Species	Tigri pagar Random Quad. 1 A	C	Tigri pagar Random quad. 2 A	C	Machkot Random quad. A	C	Dhan punji Random quad. 1 A	C	Dhan punji Random quad 2 A	C	Frequency
1	*Shorea robusta*	2	90	6	95	3	90	4 (3±)	80	3	60	100
	(Average ht. of tree)		95'		95'		85'		80'		55'	
2	*Eugenia jambolana*	1	40	...	...	...	...	...	...	...	...	20
3	*Diospyros melanoxylon*	1	50	...	...	...	...	...	...	...	...	20
4	*Anogeissus latifolia*	...	...	...	...	1	20	1	5	...	...	40
5	*Terminalia tomentosa*	...	...	...	...	...	...	1	60	...	...	20
6	*Pterocarpus marsupium*	...	...	...	...	...	...	...	...	1	30	20
7	*Madhuca latifolia*	...	...	...	...	...	...	1	20	1	5	40
8	*Buchanania latifolia*	...	...	...	...	...	...	1	10	...	...	20
9	*Odina wodier*	...	...	...	...	1	20	...	...	...	...	20
10	'Roli'	...	...	...	...	1	10	...	...	...	...	20
	Degree of slope	±		±		±		2		±		
	Degree of boulders	±		±		±		±		±		
	Degree of litters (Scale—0 to 5)	5		3		1		3		2		

5. South Raipur Division (Nagri Risgon) Forests:

Maps 5*a* and 5*b* show Kharka and Karka Ranges, respectively.



Map 5 (*a*) . Nagri range (. Raipur Division)



Map 5 (*b*) Risgaon range (S. Raipur Division)

Kharka (Nagri range) and Karka (Risgan range) represent one of the finest quality of reserved Sal forest in the state. Trees are 90 feet or more in height

TABLE 5 (*a*)

Quantitative characters of Nagri range (South Raipur) forests.

LOCALITY : At Donga tola near Nagri & Kharka on the bank of Sondul river.
GEOLOGY : Archeans.

SLOPE : Plain
PACE OF SLOPE : ×
DATED : 10-3-57

Belt transect at Donga tola runs from main road to east-west direction ; quadrats at 20' interval

No.	Species	DONGATOLA Belt transect						Frequency	KHARKA Random samples								Frequency
		A	C	A	C	A	C		A	C	A	C	A	C	A	C	
1	*Sheorea robusta*	3	90	3 (5±)	95	2	80	100	(4±)	...	2	95	1	90	1	80	100
	(Average ht. of trees)		95'		95'		95'					120'		100'		90'	
2	*Semicarpus anacardium*	1	20	...	...	...	...	33	...	...	...	...	...	...	...	...	×
3	*Buchanania latifolia*	1	10	...	...	...	...	33	...	...	...	...	...	...	...	...	×
4	*Tectona grandis*	...	...	...	...	...	...	×	1 (3±)	50	...	...	...	...	2	60	50
5	*Eugenia jambolana*	...	...	...	...	1	25	33	1	30	...	...	...	...	...	...	25
6	*Diospyros melanoxylon*	1	2	...	...	...	...	33	...	...	...	...	...	...	...	...	×
7	*Corthamus tinctorius*	1	5	1	5	...	...	66	...	...	...	...	...	...	...	...	×
8	*Cassia fistula*	...	...	...	...	...	...	×	1	20	1	5	...	...	...	...	50
	Degree of slope Degree of boulders Degree of litters (Scale—0 to 5)	± ± 3		± ± 3		± ± 3			± ± 3		± ± 4		± ± 3		± ± 3		

TABLE 5(b)

Quantitative characters of Risgan range (South Raipur) forests

LOCALITY : On the banks of Sondul river (Karka) and Risainath forests. SLOPE : ×

GEOLOGY : Archeans. FACE OF SLOPE : ×

DATED : 11/12-3—1957.

(*N. B.*—By belt transect and random samples.)

Direction of belt—East-West, quadrat 20' ± interval.

Number	Species	Karka Belt transect 1 A	C	2 A	C	3 A	C	Frequency	Random samples Karka 1 A	C	2 A	C	Biram gaon A	C	Risainath 1 A	C	2 A	C	Circular road A	C	Frequency
1	*Shorea robusta* ...	2	90	1	90	1	90	100	1 (4 ±)	90	1	90	6	80	(6±)		7 (20±)	70	9 (5±)	60	100
	Average height of trees.	120'		120'		100'		...	120'		120'		80'		...		60'		55'		
2	*Tectona grandis*	...	...	1	40	...	...	33	1 (±)	60	...	...	...	...	1	35	...	...	...	...	33
3	*Terminalia tomentosa*	...	...	...	...	1	25	33	...	...	1	50	...	...	1	50	3	25	1	25	66
4	*Eugenia jambolana*	1	60	...	...	1	25	66	2	80	...	...	...	...	...	...	...	...	...	...	16·6
5	*Anogeissus latifolia*	...	...	...	...	...	...	×	1	20	1	10	...	...	...	...	...	...	...	...	33
6	*Adina cardifolia*	1	5	...	...	...	...	33	...	...	...	...	...	...	...	...	...	...	...	...	×
7	*Cassia fistula*		...	1	10	...	...	33	..	...	...	...	...	...	...	...	1	5	...	...	16·6
8	*Madhuca latifolia*	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	1	10	16·6
9	*Diospyros melanoxylon.*	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	1	5	...	...	16·6
10	*Bauhinia sp.*	...	...	...	...	...	...	×	...	...	...	...	...	...	(2±)	...	...	...	...	...	16·6
11	*Mimosa sp.*	...	...	...	...	...	...	×	..	...	...	...	...	...	(1±)	...	...	...	...	...	16·6
	Degree of slope ...	±		±		±			±		±		±		±		±		±		
	Degree of boulders	±		±		±			±		±		±		±		±		±		
	Degree of litters (Scale 0 to 5)	4		4		4			4		4		2		±		±		±		

growing gregariously with high sociability in close forests. The main character of Nagri and Risgan forests is that Teak grows in association with Sal.

South Raipur have Cuddapah rock formation. In all 14 tree species have been observed to grow with Sal in these forests (table 5a, 5b). The important associates of Sal are *Tectona grandis, Terminalia tomentosa, Eugenia jambolana* and *cassia fistula*. The other common species are *Anogeissus latifolia, Diospyros melanoxylon* and *Corthamus tinctorius*. The upper layer of the forest is formed by Sal along with *Tectona grandis, Terminalia tomentosa, Eugenia jambolana* and *Anogeissus latifolia*. The ground flora of the forests is usually covered with litters, saplings of Sal and Tcak and other forbs.

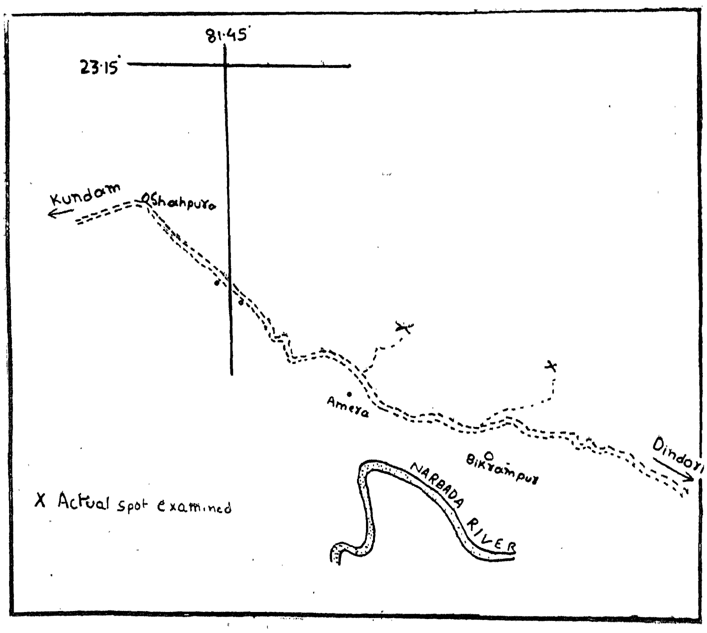
Average quantitative characters of South Raipur Sal forests (table 7) show that Sal occurs with 2·5 number of trees per quadrat covering 75 per cent of the ground. Needless to add that Sal occurs with 100 per cent frequency in these forests. It is interesting to note that regeneration of Sal and Teak are in proportion to their abundance value.

Areas which have been cleared up by cutting and burning, are characterised by stump regeneration of Sal. In Teak plantations which are even 15 years old, Sal saplings are found to grow luxuriously. These saplings of Sal and other forbs are regularly weeded out from teak plantations by forest department. However, in open areas grass species like *Themeda caudata, Eragrostis uniloides, Heteropogon contortus* and *Arundinella* sp. have been observed.

A study of density diagram (fig. 1) reveals that dominance of Sal has been interrupted by high values for frequency classes 'A' and 'B' hence, forests appear less homogeneous.

6. **Mandla Division** (Aamer & Bikrampur) **forests—**

The forests of Aamer and Bikrampur (Map. 6) are open forests and are confined to few patches. The quality of Sal tree is poor and is included in III and IV



Map 6. Aamer and Bikrampur (Mandla Division).

TABLE 6

Quantitative characters of Aamer and Bikrampur (Mandla Division) forests.

LOCALITY : Near Aamer and close to Ameli tola.

GEOLOGY : Basalt.

SLOPE :

FACE OF SLOPE : To wards south at Aamer.

DATED : 22-4-1957 and 13-6-1957

(*N. B.*—by belt transect and random samples)

Belt transect at Amli tola runs east-north direction, quadrat + 20' interval.

Number	Species	Aamer Random samples						Amli tola Belt transect						Frequency	
		1		2		3		1		2		3		In belt transect	Average value.
		A	C	A	C	A	C	A	C	A	C	A	C		
1	*Shorea roubsta* ...	1	50	5	80	4	70	4	60	(10±)	...	(8±)	...	100	100
	Average height of trees	(10±)	...	(10±)	...										
		50'		45'		45'		35'							
2	*Anogeissus latifolia* ...	1	30'	...	...	...	...	...	...	...	...	...	...	×	16·6
3	*Bauhinia racemosa* ...	3	40	...	...	...	...	...	...	...	...	(1±)	...	33	33
4	*Bauhinia anguina* ...	(5±)	...	...	...	...	...	...	...	...	...	...	...	×	16·6
5	*Terminalia tomentosa* ...	...	...	...	...	1	5	...	...	(2±)	...	...	...	33	33
6	*Odina wodier* ...	1	2	...	...	...	...	...	...	...	...	...	...	×	16·6
7	*Phyllanthus emblica* ...	...	...	...	...	1	2	...	...	...	...	...	...	×	16·6
8	*Diospyros melanoxylon* ...	...	...	...	...	...	...	(5±)	...	(5±)	...	(1±)	...	100	50
9	*Madhuca latifolia* ...	...	...	...	...	...	...	...	...	...	...	(1±)	...	33	16·6
10	*Embelia robusta* ...	...	...	...	...	...	...	...	...	...	...	(1±)	...	33	16·6
11	'Dhankot' ...	...	...	...	...	...	...	...	...	...	...	(1±)	...	33	16·6
12	'Khusia' ...	...	...	...	...	...	...	...	...	...	...	(1±)	...	33	16·6
	Degree of slope ...	5		3		2		2		5		7			
	Degree of boulders (Scale 0 to 5)	±		±		±		2		2		1			
	Degree of litters (Scale 0 to 5)	3		3		3		3		3		3			

quality of Sal classes (*cf.* Maitland, 1924). Trees grow only upto 50 feet in height and never growing in pure stands.

Mandla rocks have been classified as basalt.

Sal is found to grow with 10 other species (table 6). The frequent associates are *Terminalia tomentosa, Bauhinia racemosa, Anogeissus latifolia, Buchanania latifolia Madhuca latifolia Odina wodier, Phyllanthus emblica,* 'Dhankot', and *Embelica robusta* and 'Khusia'. The upper layer of the forests is of Sal, *Terminalia tomentosa, Anogeissus latifolia, Phyllanthus emblica* and *Madhuca latifolia.* This ground flora is usually represented by Sal saplings *Bauhinia* sp., *Embelica robusta,* 'Dhankot' and 'Khusia'. Grasses are represented by *Iseilema* sp., and *Themeda* sp.

The average quantitative characters of Aamer and Bikrampur Sal forests (table. 7) show that Sal dominates the forests. On an average 2·33 trees of Sal occurs per quadrat having 43·3 percent cover. The presence of 8 saplaings of Sal as an average value in each quadrat indicates heavy regeneration of Sal.

The forest vegetation outside Sal patches shows the dominance of *Madhuca latifolia* growing in association with almost the same vegetation as observed in Sal forests.

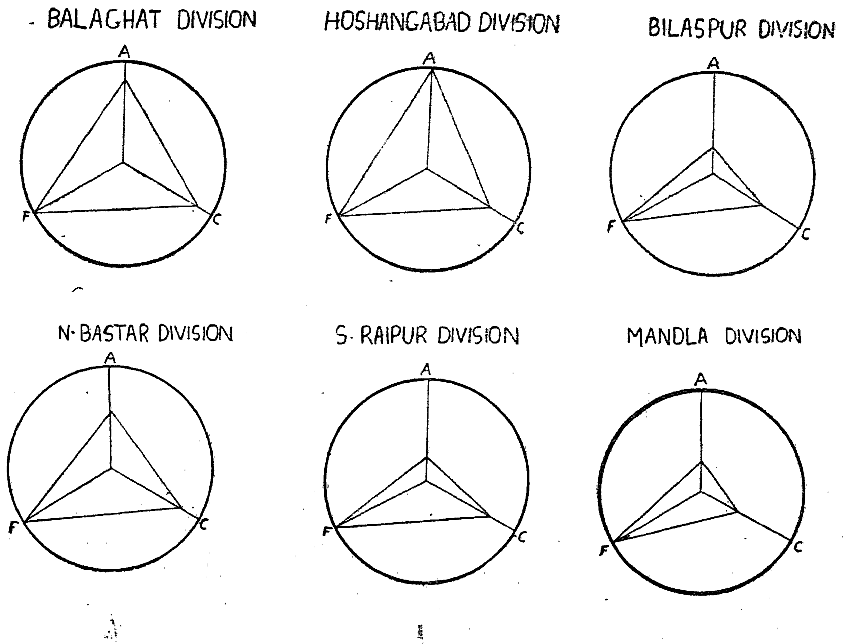
Density diagram (fig. 1) shows high degree of homogeneity in Sal forests of Aamer and Bikrampur.

RESULTS AND DISCUSSIONS

I. Analytic Characters —

(*a*) *Quantitative characters*—In all the forests studied Sal is spread with 100 percent frequency and 43.3 to 86 percent cover (fig. 3). The greatest cover has been observed at Mukie (Balaghat division). Mandla has least percentage cover of Sal and lowest value for abundance, which may be due to the effect of biotic operations. It may be added that saplings of Sal in all the forests are quite fresh and healthy. Average number of Sal saplings in the observed division varies from 0-6 to 9·1. Mandla and Balaghat divisions have high regeneration values. On an average 2 to 7 trees of Sal fall in each quadrat (table 7). Mukie forests which have tall and close trees, have about 6 trees in each quadrat. It is interesting to note that in South Raipur (Nagri & Risgan) Teak is closely associated with Sal having 15% cover. All the forests are homogeneous having Sal as a dominant tree. However, from density diagrams (fig. 1) it appears that Balaghat, Pachmarhi and Mandla forests are homogeneous to a high degree. Although Bilaspur, North Bastar and South Raipur have better quality of Sal, yet due to the preponderance of frequency classes 'A' and 'B', forests become less homogeneous. A number of second story and ground flora have contributed to the lower degree of homogeneity.

(*b*) *Qualitative characters* —Trees are mostly hypodispersed. Almost pure forests have been observed, e.g., Mukie (Balaghat division). The main associates which occur in 4 out of 6 divisions examined are, *Terminalia tomentosa, Madhuca latifolia, Pterocarpus marsupium, Buchanania latifolia* and *Anogeissus latifolia* The species of second layer are *Cassia fistula, Adina cordifolia, Corthamus tinctorius, Semicarpus anacardium, Bauhinia* sp. and 'Roli' etc. Ground flora is generally dominated by Sal saplings. Other flora is usually poor and rarely present, which is represented by *Imperata cylindrica, Arundinella* sp., *Apluda mutica, Cymbopogon martini, Heteropogon contortus, Iseilema* sp. *Oplicimanus* sp. and *Themeda* sp. Sociability of this tree is very high and the tree



A - ABUNDANCE (Average Value) - 0 to 6·22   F - P.C. FREQUENCY (Average Value) - 0 to 100   C - P.C. COVER (Average Value) - 0 to 100

POLYGRAPHS SHOWING DISTRIBUTION OF A SAL TREE (AVERAGE VALUE) IN DIFFERENT FORESTS OF M. P.

Fig. 3.

occurs in closed colonies. Thus, it appears that Sal is biologically well equipped for development and distribution in its surroundings.

The homogeneity of the observed forests has been further explained by the synthetic character "Constance" which records the occurrence of a particular species in different stands of the same community. No other species except Sal is found to have high constance value (table 8). Only *Terminalia tomentosa* has been observed to have constance value 4 in one of the forests examined (Mukie, Balaghat division). Sal survices any interspecific competition; sporadic or accidental species do add to the flora of Sal forests but they can not be called as companion speceis. On an average 8 tree species are found to be associated with Sal in the examined divisions except South Raipur where it has been observed to grow with 14 different species. In good quality of Sal forests trees grow upto 90 feet or more in height as in South Raipur, North Bastar and Mukie (Balaghat). In these forests Sal cover varies from 75 to 86 percent. The number of trees per quadrat is, however, greater in Mukie. A diagrammatic representation of the percentage cover and height of single Sal tree from the divisions examined is presented in fig. 2. South Raiphr Sal exceeds all the observed divisions in height which is followed by North Bastar and Balaghat forests. The greatest percentage cover has been noted in Bilaspur whereas South Raipur falls next in line. Sal trees of Pachmarhi (Hoshangabad division) and Mandla represent poor growth in height and percentage cover.

It appears that Sal has a localised distribution, having hypodispersion, high sociability figures and high fidelity value.

TABLE

Quantitative characters of Sal (*Shorea robusta* Gaertn) forests

No.	Species		BALAGHAT DIVISION (Mukie forests)			HOSHANGABAD DIVISION (Pachmarhi forests)		
			A	F	C	A	F	C
1	*Shorea rabusta*	..	6·130 (9·1±) 'B'	100	86·00	6·22 (0·88±) 'D'	100	66·66
2	*Tectona grandis*	...	...	...	...	...	...	...
3	*Terminalia tomentosa*	...	2·130	64	12·80	0·22	22	3·88
4	*Eugenia jambolana*	...	...	...	...	...	...	...
5	*Anogeissus latifolia*	...	...	...	...	0·55	11	3·30
6	*Buchanania latifolia*	...	(0·5±)	33	...	0·55	14	5·50
7	*Cassia fistula*	...	...	...	...	...	...	—
8	*Diospyros melanoxylon*	...	...	...	...	4·40	22	0·55
9	*Adina cordifolia*	...	...	...	...	(0·88±)	...	—
10	*Corthamus tinctorius*	...	...	...	...	...	...	...
11	*Semicarpus anacardium*	...	...	...		...	...	...
12	*Mabhuca lotifolia*	...	0·166	16	0·17	...	22	3·00
13	*Pterocarpus marsupium*	...	(0·166±)	16	...	0·33	11	0·22
14	*Bauhinia recemosa*	...	...	...	...	0·11	...	...
15	*Bauhinia anguina*	...	...	...	...	...	...	...
16	*Odina wodier*	...	...	...	...	...	...	...
17	*Cleistanthus collinus*	...	...	—	...	...	...	..
18	*Saccopetalum tomentosum*	...	...	...	...	...	11	0·55
19	*Careya arborea*	...	0·330	33	1·83	0·11	...	...
20	*Phyllanthus emblica*	...	0·166	16	0·33	...	.	...
21	*Embelica robusta*	...	...	...	...	...	...	...
22	*Butea monosperma*	...	...	...	...	...	...	..
23	*Ficus religiosa*	...	...	...	...	...	...	...
24	*Terminolia chebula*	...	...	...	..	...	22	3·81
25	*Mimosa, sp.* ...	...	...	...	...	0·33	...	...
26	'Roli' ..	...	..	...	...	...	...	...
27	'Sandhu' ...	...	...	...	...	...	...	...
28	'Gonicya' ...	...	...	...	...	...	...	...
29	'Dhankot' ...	...	...	...	...	...	...	...
30	'Khusia' ..	—	...	...	...	...	—	...
31	'Doomer' ...	...	...	...	...	...	...	...

7.

in different divisions of Madhya Pradesh, (Average value)

BILASPUR DIVISION (Lormi and Baikuntpur)			N. BASTAR DIVISION (Tiria forests)			S. RAIPUR DIVISION (Nagri and Risgan)			MANDLA DIVISION (Aamer and Bikrampur)		
A	F	C	A	F	C	A	F	C	A	F	C
1·830	100	59·29	3·6	100	83	2·5000	100	74·370	2·33	100	43·30
(2±)			(0·6±)			(2·75±)			(8±)		
'C1'			B1'			'A'			'D'		
...	...	...	...	...	-	0·3750	31	15·300	...	...	...
...	...	...	0·2	20	12	0·4300	31	10·900	0·166	33	0·83
...	...	...	0·2	20	8	0·3750	31	13·750	...	...	...
...	...	...	0·4	40	5	.0·1250	13	1·880	0 166	16	5·00
0·571	30	4·28	0·2	20	2	0·0625	6	0·625	...	...	...
...	...	...	--	--	...	0·250	25	2·50	...	...	...
...	...	...	0·2	20	10	0·1250	13	0·430	(1·83±)	33	...
...	...	...	...	...	...	0·0625	6	0·330	...	...	...
...	...	...	...	...	...	0·1250	13	0·625	...	-	...
...	...	...	...	...	...	0·0625	6	1·250	...	...	...
...	...	...	0·4	40	5	0·0625	6	0·625	(0·166±)	16	...
0·142	15	5·70	0·2	20	6	...	...	...	...	...	...
0·142	15	2·85	...	...	...	(0125±)	6	...	0·5	32	6·60
...	...	...	...	...	...	...	...	...	(0·825±)	16	...
...	...	...	...	20	2	...	...	...	0·166	- 16	- 0·33
0·428	15	5·70	...	...	...	...	...	..	...	---	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...		...	...	...	...	0·166	16	0·33
...	...	...	...	...	...	...	...	...	(0·166±)	16	...
0·142	15	3·57	...	...	—	...	...	...	...	...	...
0·142	15	4·28	...	...	...	...	...	...	...	...	...
...	...	...	...	—	...	--	...	...	...	...	...
...	...	...	...	...	...	(0·0625±)	6	...	...	...	...
0·142	15	2·85	0·2	20	2	...	...	...	...	...	...
0·570	30	5·70	...	...	...	...	...	...	...	...	...
0·142	15	2·85	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	(0·166±)	16	...
...	...	...	...	...	—	...	—	...	(0·166±)	16	...
...	...	...	...	...	...	0·0625	6	0·660	...	...	...

Average height of trees 90' or more ... 'A'.
" " " " 81' to 90' ... 'B1'.
" " " " 71' " 80' ... 'B'.
" " " " 61' " 70' ... 'C1'.
" " " " 51' " 60' ... 'C'.
" " " " 35' " 50' ... 'D'.

TABLE 8

Synthetic characters of Sal association in different divisions of M. P. Constance in the scale of 0 to 5.

No	Species	BALAGHAT (Mukie)	HOSHANGA BAD (Pachmarhi)	BILASPUR (Lormi & Baikuntpur)	N. BASTAR (Tiria & forests)	MANDULA (Nagri & Risgan)	S. RAIPUR (Amar & Bikrampur)
1	*Shorea robusta.* ...	5	5	5	5	5	5
2	*Tectona grandis* ...	...	...	...	...	2	...
3	*Terminalia tomentosa*	4	1	...	1	2	2
4	*Eugenia jambolana*	...	...	...	1	2	2
5	*Anogeissus latifolia* ...	...	1	...	2	1	1
6	*Buchanania latifolia*	2	2	1	1	1	...
7	*Cassis fistula* ...	...	...	...	...	2	...
8	*Diospyros melanoxylon*	...	1	...	1	1	...
9	*Adina cordifolia* ...	...	...	...	...	1	...
10	*Corthamus tinctorius*	...	...	...	...	1	...
11	*Semicarpus anacardium*	...	...	...	...	1	...
12	*Madhuca latifolia* ...	1	1	...	1	1	1
13	*Pterocarpus marsupium*	1	1	1	1	...	...
14	*Bauhinia racemosa* ...	...	...	1	...	1	2
15	*Bauhinia anguina* ...	...	...	...	---	...	1
16	*Odina wodier* ...	...	...	...	1	...	1
17	*Cleistanthus collinus*	...	...	1	...	...	...
18	*Saccopetalum tomentosum*	...	1	...	...	...	...
19	*Careya arborea* ...	2	...	...	—	...	...
20	*Phyllanthus emblica*	1	...	...	—	...	1
21	*Embelica robusta* ...	...	...	...	...	...	1
22	*Butea monosperma* ...	...	...	1	...	...	...
23	*Ficus religiosa* ...	...	...	1	...	...	...
24	*Terminalia chebula*	...	1	...	...	...	...
25	*Mimosa sp* ...	...	...	...	...	1	...
26	'Roli' ...	...	...	1	1	...	...
27	'Sandhu' ...	...	...	2	...	...	...
28	'Gonicya' ...	...	...	1	...	...	...
29	'Dhankot' ...	...	...	...	...	...	1
30	'Khusia' ...	...	...	...	—	...	1
31	'Doomez' ...	...	...	...	...	1	...

SUMMARY

The paper deals with a study of the pattern of distribution of Sal and its associates in the localised Sal regions of Madhya Pradesh.

The Sal regions under investigation are : Balaghat division (Mukie forests), Hoshangabad division (Pachmarhi forest), Bilaspur division (Lormi & Baikuntpur forests), North Bastar division (Tiria forests), South Raipur (Nagri & Risgan forests) and Mandla division (Aamer & Bikrampur forests). The forests have been studied by belt transect (20 feet wide alternate quadrats run across the contours), and random samples. The size of the quadrat (20'X20') has been arrived at by species area curve.

Analytic characters including qualitative and quantitative and synthetic characters of the forests have been described. The paper further gives density diagrams of the different forests and polygraphs showing abundance, frequency and cover of Sal in these regions.

In total about 31 tree species have been recorded to grow with Sal in the different forests examined. None of them is a constant associate of Sal. The following species occur in at least 4 out of 6 divisions studied : *Terminalia tomentosa, Madhuca latifolia, Pterocarpus marsupium, Buchanania latifola* and *Anogeissus latifolia.* Layering is present in the forests. Sociability of Sal is great. Heavy regeneration adds to the sociability value. South Raipur division (Nagri & Risgan) has the best Sal growth, having 90 feet or more tall trees and good cover. On an average 2·5 number of adult Sal plants with 74.37% of cover and 2 to 3 saplings occur in each quadrat in this division. Bastar (Tiria forests) and Balaghat division (Mukie forests) fall next in line. The trees are 70 to 90 feet tall with 83 to 86 percent of cover, respectively. Number of trees however, is greater in Mukie quadrats. Pachmarhi (Hoshangabad division) and Aamer & Bikrampur (Mandla division) forests have poor growth with 66·66% and 43·3% of cover respectively.

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REFERENCES

Bose, P. N. 1884 quoted by "Khan, M.A.W. (1953)—Ind. For. 79 : no. 9.

Bourdeau, Phidlippe F. 1953 A Test of Random versus Systematic Ecological sampling. Ecology. 34: no. 3.

Champion, H. G. 1933 "Regeneration and management of Sal", Ind. For. Record, vol. XIX, Pt. III.

Finney, 1949 "An example of periodic viriation in the forest samplings." Forestry 23:96—111.

Hewetson, C.F. 1953 Discussion on ecological position of Sal (*Shorea robusta*) Ind. For. 79, no. 6.

Khan, M. A. W. 1953 Effects of geological formations on the distribution of Sal (*Shorea robusta*), in Madhya Pradesh forests. Ind For. 79, no. 9.

Maitland, V. K. 1924 Volume tables for (*Tectona grandis*) teak and (*Shorea robusta*) Sal forests for Central provinces. Ind. For. Rec. 11 (7): 215—222.

Mistra, R. 1957 Plant Ecological studies in Madhya Pradesh. Presidential address. Biol. Sci., Nat. Acad. Sci, 27th session.

Misra, R. & G. S. Puri 1957 Indian manual of plant Ecology. English book depot. Dehra Dun.

Mooney, H. F. 1947 "A note on Southern limit of Sal (*Shorea robusta*) in Orissa and Bastar State". Indian Ecologist, 1 (27-31).

Oosting, H. J. 1948 The study of Plant communities. W. H. Freeman & Co. San Franscisco, California.

Pandeya, S. C. 1953 Ecological studies of grasslands of Sagar. Ph. D Thesis, Saugar Univ.

Puri, G. S. 1954 Problems in the ecology of Sal (*Shorea robusta*) in Madhya Pradesh. Bull. Bot. Soc. Saugar Univ.

Sathe, P. G. 1951 The role of geology in the distribution of Sal and other plants comunities in some forsts of Madhya Pradesh. Proc. 8th Silv. Conf, Dehra Dun.

Shanks, Royal E. 1953 Forest composition and species association in the Beech maple forest region of western Ohio. Ecology. 34:, no. 3.

Troup, R. S. 1921 "The Silvicultulture of Indian Trees", vol. I, Oxford.

STUDIES ON THE SPORE CHARACTERS OF *ALTERNARIA TENUIS* AUCT SENSU STR.

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The spore characters of *Alternaria* are of great importance because the determination of species is largely dependent on them. They are, however, seldom consistent under all environmental conditions. Elliot (1917) gave a graphical presentation of the spore measurements of eight species of *Alternaria* after growing them on 5 to 11 media. The influence of the medium was particularly marked in case of *Alternaria iridicola* (Ell. Ev.) Elliot and *A. sonchi* Davis. Similarly Bolle (1924) found considerable difference in the form and size of spores of *A. brassicae* and *A. solani* and Neergaard (1945) observed it in *A. brassicae, A. dianthi, A. dianthicola* and *A. porri*. Groves and Skolko (1944) expressed, "Although the unnecessary multiplication of species of fungi is to be avoided............ ....nevertheless it is a recognised principle of science that analysis must precede synthesis. Thus in groups of fungi in which the range of variation is not clear, the taxonomic value of the characters is uncertain". It was, therefore, felt desirable to make a detailed investigation of the morphological characters of *A. tenuis* under several environmental conditions.

MATERIALS AND METHODS

Single spore cultures were maintained on a basal medium containing glucose 15 gms, potassium nitrate 3·608 gms, potassium dihydrogen phosphate 1·75 gms, magnesium sulphate 0·75 gms, and distilled water 1 litre. Solidification, where necessary, was effected by the addition of 2% bacto-agar. The experiments were carried out on liquid media and for that purpose 50 c.c. of the solution was taken in 150 c.c. Erlenmeyer flasks. Autoclaving was carried out at 15 lbs. pressure for 15 minutes and the cultures were incubated at 25°c. for 21 days.

In order to determine the effect of various carbon or nitrogen compounds, these were substituted singly in the medium by replacing the original corresponding compound (either glucose or potassium nitrate). The amount of the substituted substance was so adjusted as to contain the same quantity of carbon or nitrogen which was present in the basal medium. The amount of polysaccharides was similar to that of glucose and that of peptone to KNO_3. In order to avoid excessive caramelization of the sugars, fractional sterilization on three successive days was carried out for the experiments dealing with carbon requirements. In experiments of trace elements, all customary precautions were rigidly observed. The method suggested by Steinberg (1935) was used for the study of the effects of trace elements. The following substances were included in the present investigation: ammonium molybdate for Mo, mangnese chloride for Mn, calcium nitrate for Ca, cupric chloride for Cu, ferrous sulphate for Fe and zinc chloride for Zn. They were added to separate aliquots of the filtrate in three concentrations viz., 0·001%, 0·0001% and 0·00001% respectively. The solutions were reautoclaved. Inoculations were made from spore suspensions prepared in double distilled water and care was taken to have more or less similar concentration of spores in different experiments.

The results of the size and septation of muriform spores are based on measurements of fifty spores. It may be mentioned that generally 10-15 muriform spores were present in each low field of the microscope. Thus about 3·5 different mounts were prepared from the centre of the colony of each flask.

The following formulae were employed for calculations of significant difference in connection with size and septation of spores :

$$\text{Standard deviation} = \frac{\text{Sum of deviation}}{n - 1}$$

$$\text{Standard error} = \frac{\text{Standard deviation}}{n}$$

The test of significance between two values was found out by evaluating the value of:

$$\frac{\text{difference between the two means}}{\text{standard error of differenee}}$$

when

$$\text{Standard error of difference} = \sqrt{S.\,E._1^{\,2} - S.\,E._2^{\,2}}\,*$$

Wherever the calculated value of t was greater than 2·01 (the value of t at 5% level of P for 49 degrees of freedom), the difference between the two means was taken to be significant.

Ridgway's "*Colour Standards and Nomenclature*" was used for determining the colour of spores and hyphae.

OBSERVATIONS

Spore characters on the basal medium.—The initial growth of the fungus on the solidified basal medium was marked by the development of white, cottony aerial hyphae which were subsequently suppressed owing to copious sporulation. The colour of the colony was generally brownish drab. Occasionally the centre appeared chataeura-black. The aerial hyphae were colourless and branched. Their thickness varied from 2·7 to 4·0μ. The trophic hyphae were similar to the aerial ones except that they were olive-buff in colour.

The spores were borne in chains on long conidiophores which were similar to trophic mycelia (Fig. 1 A-C). The chain usually consisted of about 8-10 spores. On rare occasions, some chains with larger number of spores were observed. The attachment of spores was found to be extremely delicate, and due to this, long chains could never be seen on slides. They could, however, be seen at the periphery of colonies growing on solid media.

Examination of the spores from cultures of different ages confirmed the observations of Tandon (1945) according to whom muriform, uniseriate, bicelled and single celled spores could be associated together and all types were capable of independent germination (Fig. I D. & E.) Their percentages in cultures of different ages are given in Table 1.

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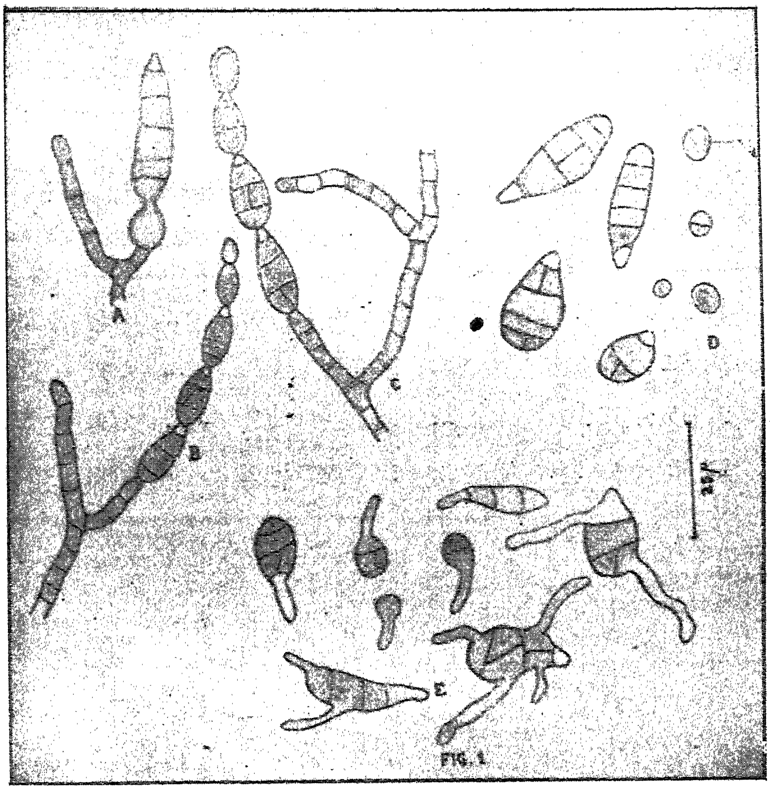
*S. E.=Standard error.



A, spore in the act of budding ; B-C, Conidia in chains borne on conidiophore ; D, Different types of spores—single celled, bicelled, uniseriate and muriform. The bicelled type, marked—X shows the separation by protoplasmic membranes and not by septa. E, germinating spores.

TABLE 1

Showing percentage of various types of spores taken from cultures grown for different period.

Age of colony		Type of spores			
		Muriform	Uniseriate	Bicelled	Single celled
7 days	...	68·2	24·5	3·0	4·3
15 days	...	72·9	23·4	3·1	0·6
21 days	...	83·2	13·5	3·1	0·2
30 days	...	89·0	9·0	1·6	0·4

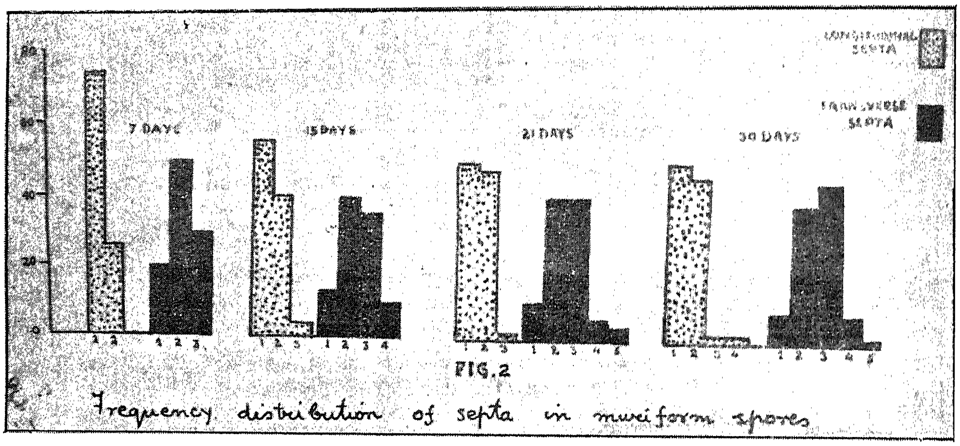
The table shows that the percentage of muriform spores increased with the age of the colony. On the other hand, the percentage of uniseriate, bicelled and single celled forms decreased but none of them were completely eliminated.

The mean size and septation of muriform spores were also examined as regular intervals. The results are summarized in Table 2.

Table 2—Showing mean size and septation of spores at different intervals.

Age of colony	Mean size	Mean septation	
		Longitudinal	Transverse
7 days ...	21·50 × 10·80 ...	1·26 ± 0·0445 ...	2·10 ± 0·0707
15 days ...	24·32 × 14·67 ...	1·48 ± 0·0569 ...	2·42 ± 0·0858
21 days ...	25·65 × 14·10 ...	1·52 ± 0·0543 ...	2·54 ± 0·0992
30 days ...	25·38 × 14·17 ...	1·56 ± 0·0545 ...	2·58 ± 0·0846

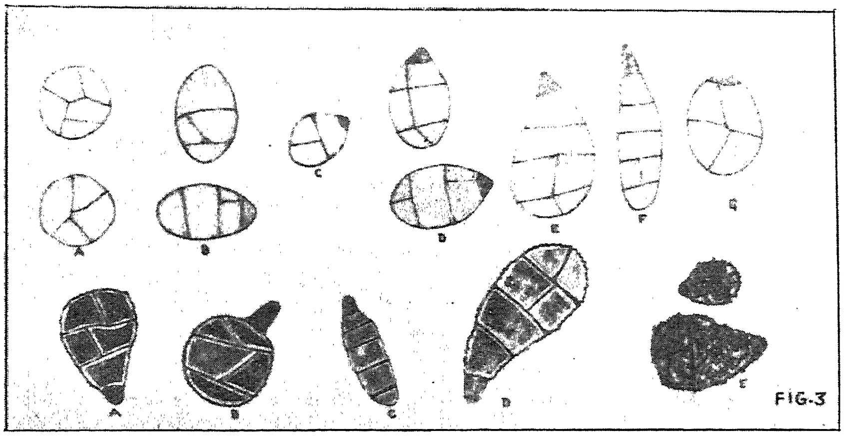
The above table shows that the mean size and mean septation of spores did not differ significantly in 15, 21 and 30 days old cultures. There was, however, significant difference between the results of 7 days and 21 days old cultures. Fig. 2



Percentage frequency of longitudinal and transverse septa in muriform spores.

shows the percentage of transverse and longitudinal septa in different muriform spores. It is evident that at the early stage (*viz.* 7 days old cultures), the proportion of spores with one longitudinal septum and 2 to 3 transverse septa was most pronounced, but as the time increased both longitudinal and transverse septa increased. The maximum number of septa observed in the spores on this medium were 4 longitudinal and 5 transverse.

The position of the development of longitudinal septa was not constant. They could start in any cell except in the beak region.



(i)

(ii)

(i). Different forms of spores. A, beakless sperical; B, beakless elliptical; C, beaked ball shaped; D, beaked elliptical; E, beaked conical; F, beaked cylindrical and G, beaked globular.

(ii). A-E, muriform spores showing different degree of verrucosity of their wall. E, the spore wall is markedly warty and the contents are dark and septa are not seen clearly.

The spores of *A. tenuis* were found to be most polymorphous (Fig. 3). A count of 200 muriform spores from twenty one days old cultures showed the following types :—

1. *Beakless*
   - (*a*) oval (3%)
   - (*b*) ball shaped (1·5%)
2. *Beaked*
   - (*a*) ball shaped (0·5%)
   - (*b*) oval (28%)
   - (*c*) conical (42%)
   - (*d*) Cylindrical (25%)

The most common type was the beaked conical form followed by oval and cylindrical ones. Beaked as well as unbeaked ball shaped forms were very infrequent. Rarely globular ones were observed. The colour of spores was also very variable. Even in the same microscopic field, all the spores were not of the same colour even though they may be otherwise quite similar and may even be of the same age. In general, the colour was dark olive buff though other shades ranging from olive buff to dark olive buff or even deeper colour were also observed. Only the beak region remained faintly olive.

The spore wall also presented variable features. It could be smooth or verrucose (Fig. 3 (ii)). Their percentage in cultures of different ages are given in table 3.

TABLE 3

Showing the percentage of smooth walled and verrucose type of spores of *A. tenuis* at different ages.

Days	Smooth walled	Verrucose
7	98	2
15	69	31
21	36	64
30	21	79

It is obvious that the percentage of verrucose type of spores increased with age of the cultures. The spores from cultures stored for about two months were also examined and it was found that in general the percentage of verrucose spores was above 90%, but even in very old cultures all the spores did not develop verrucose type of wall. It was also observed that the smooth walled spores in such cultures were generally single-celled or bicelled. Smooth walled uniseriate and muriform spores were extremely few.

The septa appeared distinctly in almost all the spores except in some bicelled or uniseriate types or in those very old cultures in which the pigmentation was very deep. In the former case, the division of the spore was not effected by the formation of a septum or cross wall but by the abutting plasma membranes (Fig. 1 D-x). The outside wall was of uniform thickness over the whole length of the spore except at the beak region where it was thin. Generally the septa were of uniform thickness. The protoplasmic membrane was closely adjacent to the septa or wall. Examination of the spores against bright light revealed that the protoplasts had unequal densities at different regions.

INFLUENCE OF CARBOHYDRATES

The organism was grown on media containing different carbohydrates separately. The results of spore size and septation are given in table 4, and the frequency distribution of different types of septa (*viz*, transverse or longitudinal) are shown in Fig. 4.

Calculation of the values of t for mean length, breadth and mean septation of spores revealed that the mean length of the muriform spores increased significantly on media containing mannose, maltose and glycogen. It may be mentioned that some compounds supported good growth of the fungus. The maximum length (57·4 μ and breadth 21·0 μ) was observed on glycogen. Significantly smaller length was observed on sorbitol.

In other cases, there was no significant difference in the mean length of the spores.

The mean breadth of spores was also greater on media which developed significantly larger spores but the differences were not significant. The breadth recorded on starch, mannitol and sorbitol were significantly smaller than on the basal medium.

TABLE 4

Dry weight, sporulation, mean size and septation of spores of *A. tenuis* on media containing different carbohydrates

C-compound	Average dry weight	Sporulation	Mean length	Range	Mean Breadth	Range	Mean Longitudinal septation	Range	Mean trans. Septation	Range
Arabinose ...	186	**	24·0±0·654	15·0—42·4	14·0±0·31	9·0—16·8	1·34±0·079	1—3	2·94±0·098	1—5
Rhamnose ...	209	***	26·0±0·794	15·0—51·2	15 7±0·504	8·4—21·0	1·60±0·090	1—4	3·16±0·091	1—5
Xylose ...	282	***	26·4±0·892	9·8—52·6	15·2±0·533	8·8—19·8	1·66±0·119	1—5	3·16±0·117	1—6
Mannose ...	288	***	27·7±0·927	14·8—51·2	15·4±0·684	7·6—21·5	1·74±0·113	1—4	3·40±0·145	1—6
Glucose ...	198	***	24·3±0·710	14·8—52·6	14·8±0·493	8·4—14·8	1·52±0·075	1—3	3·0 ±0·090	1—5
Galactose ...	189	****	24·5±0·673	15·0—55·0	13·9±0·471	8·4—19·8	1·50±0·111	1—4	2·94±0·098	1—5
Fructose ...	129	***	24·0±0·411	13·6—46·6	13·7±0·398	8·4—16·3	1·38±0·074	1—3	2·76±0·116	1—4
Maltose ...	280	****	27·3±0·981	14·8—55·2	15·3±0·571	9·2—21·0	1·76±0·122	1—5	3·48±0·147	1—6
Sucrose ...	181	**	24·0±0·571	9·8—42·8	14·4±0·330	8·4—16·6	1·50±0·071	1—3	2·96±0·098	1—4
Lactose ...	159	**	24·1±0·591	15·0—41·7	13·7±0·421	8·4—16·6	1·30±0·073	1—3	2·62±0·112	1—5
Starch ...	102	*	23·7±0·550	12·4—42·6	13·2±0·486	8·4—16·6	1·26±0·062	1—2	2·62±0·116	1—4
Glycogen ...	242	***	26·8±0·966	13·8—57·4	15·7±0·581	8·4—21·0	1·58±0·101	1—4	3·22±0·123	1—5
Dextrin ...	239	**	25·9±0·630	11·8—42·4	15·4±0·568	9·6—19·8	1 56±0·114	1—5	3·04±0·092	1—5
Inulin ...	132	**	23·4±0·562	12·6—43·8	13·5±0·490	7·4—16·4	1·28±0·084	1—3	2·58±0·117	1—4
Arbutin ...	100	**	23·8±0·758	12·8—43·8	13 6±0·557	8·4—16·4	1·26±0·07	1—3	2·60±0·12	1—4
Dulcitol ...	84	*	22·8±0·640	12·8—44·6	13·6±0·557	8·4—16·4	1·30±0·071	1—3	2·58±0·128	1—4
Mannitol ...	51	*	23·0±0·620	11·6—41·5	13·0±0·553	8·4—16·4	1·26±0·07	1—3	2·62±0·112	1—5
Sorbitol ...	100	*	22·4±0·657	12·6—41·2	13·0±0·572	8·4—16·4	1·28±0·06	1—3	2·58±0·113	1—5
No carbon ...	...	...	...	...	...	...	...	...	...	...

S. E.—0·855

C. D. at 1%—3·2272

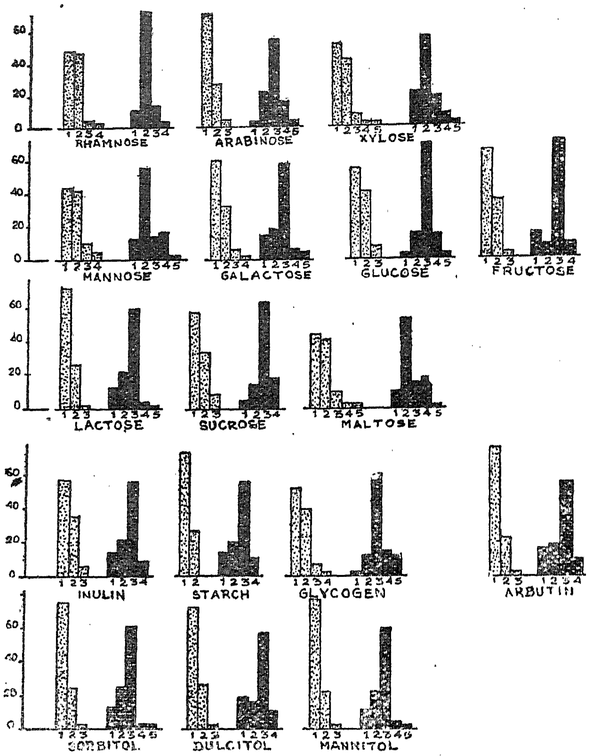


FIG. 4

Frequency distributions of number of logitudinal and transverse septa in muriform spores taken from cultures growing on media with different carbon sources.
(Signature same as in Fig. 2.)

It may be pointed out that the size of spores was not necessarily smaller on media which suported poor growth. This is evident from the fact that growth was poorer on galactose but the mean length or breadth did not differ significantly from those on the basal medium. It has also been observed that the larger spores bore larger number of tranverse septa. The number was greater on mannose and maltose which had significantly larger spores.

INFLUENCE OF NITROGEN SOURCE

A. tenuis was also grown separately on media containing different nitrogen sources. The results of spore size and septation are summarized in Table No. 5 and the frequency of transverse or longitudinal septa is shown in Fig. 5.

It is evident from the above table that the mean sizes (both length and breadth) as well as the mean septations (both longitudinal and transverse) were moderate on potasium nitrate, alanine, valine, leucine, arginine, aspartic acid, glutamic acid, asparagin and peptone, while they were smaller on media containing phenyl-alanine, tyrosine, histidine, tryptophane and urea. There was a parallelism between the type of differences observed in transverse and longitudinal septation.

TABLE 5

Dry weight, sporulation, mean size and septations of *A. tenuis* on media containing different nitrogen compomnds

N. Source	Mean dry weight	Sporulation	Mean Size of Muriform Spores				Mean Septation			
							Longitudinal		Transverse	
			Length	Range of variation	Breadth	Range of variation	Mean	Range	Mean	Range
Ammonium chloride	50	...	...	...	...	...	...	...	...	...
Ammonium nitrate	102	...	...	...	...	...	...	...	...	...
Ammonium sulphate	40	...	...	...	...	...	...	...	...	...
Ammonium oxalate	58	...	...	...	...	...	...	...	...	...
Ammonim tartarate	68	...	...	...	...	...	...	...	...	...
Potassium nitrite	0	...	...	...	...	...	...	...	...	...
Potassium nitrate	198	***	25·3±0·872	9·6—43·2	14·8±0·739	8·4—19·8	1·5 ±0·088	1—3	2·96±0·089	1—5
d-alanine	128	****	27·6±0·968	10·2—45·6	15·4±0·585	8·4—18·7	1·78±0·133	1—4	3·26±0·136	1—6
d-valine	145	****	27·21±1·15	9·8—44·8	15·0±0·571	8·4—17·9	1·70±0·122	1—4	3·1 ±0·137	1—6
l-leucine	123	***	24·75±0·427	10·2—41·6	14·0±0·514	8·4—18·6	1·48±0·095	1—4	2·86±0·091	1—5
d-arginine	120	**	24·10±0·616	9·6—45·6	13·7±0·567	6·8—16·8	1·36±0·079	1—3	2·76±0·097	1—5
l-aspartic acid	139	**	24·4 ±0·684	9·6—43·2	13·9±0·594	7·2—16·4	1·34±0·071	1—3	2·64±0·148	1—5

TABLE 5—(*Contd*)

N. Source	Mean dry weight	Sporulation	Mean Size of Muriform Spores				Mean Septation			
			Length	Range of variation	Breadth	Range of variation	Longitudinal		Transverse	
							Mean	Range	Mean	Range
d-glutamic acid	119	**	24·30±0·728	6·5—40·2	13·9±0·594	8·2—16·4	1·32±0·087	1—3	2·74±0·130	1—4
Asparagin	122	**	25·10±0·879	10·6—45·0	14·3±0·622	8·4—16·4	1·36±0·079	1—3	2·78±0·111	1—4
l-Phenylalanine	70	*	22·10±0·714	8·4—43·5	12·0±0·466	6·5—16·4	1·24±0·06	1—2	2·42±0·125	1—4
Tyrosin	100	*	22·7 ±0·666	8·4—41·8	12·0±0·466	6·5—16·4	1·26±0·07	1—3	2·48±0·111	1—4
Histidine	59	*	22·3 ±0·661	6·4—42·7	12·4±0·533	6·2—15·8	1·26±0·062	1—2	2·46±0·119	1—4
Tryptophane	68	*	22·40±0·694	6·4—42·0	12·1±0·568	6·5—15·6	1·22±0·058	1—2	2·40±0·114	1—4
Cystine	0	...	...	...	...	...	...	...	...	...
Cystein hydrochloride	0	...	...	...	...	...	...	...	...	...
Urea	62	*	22·7±0·871	8·4—42·8	12·4±0·588	7·2—16·4	1·28±0·064	1—2	2·42±0·128	1—4
Peptone	142	***	26·8±0·966	8·4—48·6	15·4±0·568	6·4—15·8	1·52±0·075	1—3	2·96±0·098	1—4
No nitrogen	0	...	...	...	...	...	...	...	...	...
S. E. =	1·02									
C. D. at 1 %	=3·8284									

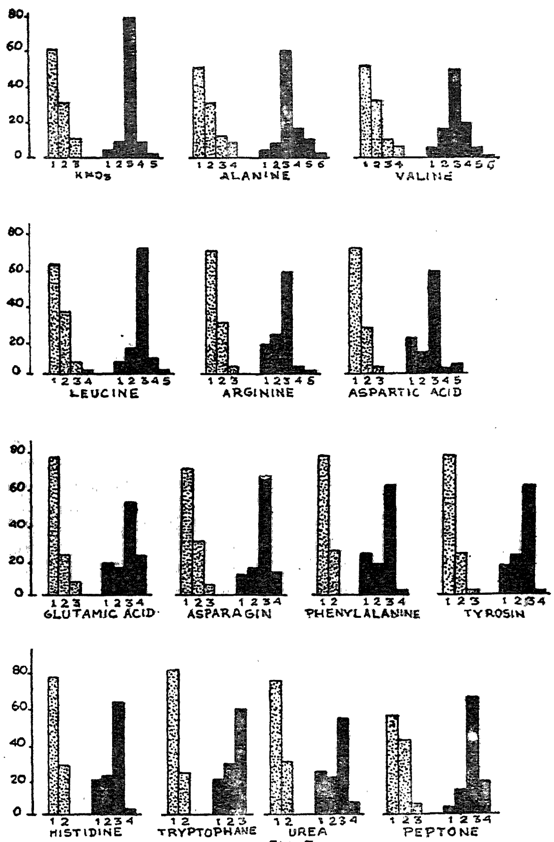


FIG. 5

Frequency distributions of number of longitudinal and transverse septa in muriform spores taken from cultures growing on media with different nitrogen sources.

The number of transverse septa varied from 1-4 on all those media which showed significantly smaller mean septation. Glutamic acid, asparagin and peptone also had the same range even though their average septation did not fall under the smaller mean. The range of longitudinal septa varied from 1—2 only on those media which showed significantly smaller mean, except on tyrosine. The maximum range was from 1-4 on media having d-alanine and d-valine. The maximum length of muriform spores was 48·6 μ on the medium containing peptone while the maximum breadth was 19·8 μ on the basal medium.

INFLUENCE OF TRACE ELEMENTS

Effect of various concentrations of six different trace elements on the spore size, shape and septation of *Alternaria tenuis* was also studicd. The results are summarized in Table 6 and Figs. 6 and 7.

The table clearly shows that even though the growth and sporulation were adversely affected under the influence of certain trace elements but the size or the septation of the muriform spores, whenever they were developed, were not

TABLE 6

Mean dry weight, sporulation, mean size and mean septation of muriform spores of *A. tenuis* on media supplemented with various trace elements.

Trace elements	Concentration in %	Mean dry weight.	Sporulation.	Size of spores				Septation			
				Mean length	Range	Mean breadth	Range	Longitudinal		Transverse	
								Mean	Range	Mean	Range
Molybdenum ...	·001	32	...	...	...	...	...	...	...	...	...
	·0001	68	*	23·6 ±0·628	9·6–42·0	13·52±0·384	4·2–18·8	1·24±0·04	1–2	2·62±0·08	1–5
	·00001	103	*	24·61±0·612	18·7–42·0	13·51±0·319	4·2–19·2	1·22±0·04	1–3	2·7 ±0·05	1–4
Manganese...	·001	128	*	24·04±0·64	6·3–46·2	14·33±0·347	4·2–21·2	1·32±0·05	1–3	2·62±0·052	1–5
	·0001	153	*	26·12±0·772	6·34–6·2	14·29±0·379	4·2–21·2	1·36±0·052	1–3	2·72±0·09	1–5
	·00001	225	***	27·72±0·648	8·4–50·4	16·08±0·338	4·2–21·2	1·6 ±0·06	1–3	2·0 ±0·09	1–5
Calcium ...	·001	202	***	25·37±0·792	8·4–50·4	14·61±0·288	4·2–21·2	1·24±0·05	1–3	2·62±0·08	1–5
	·0001	197	***	25·54±0·88	8·4–50·4	14·78±0·342	4·2–21·2	1·32±0·055	1–3	2·64±0·11	1–6
	·00001	217	***	25·28±0·856	6·3–50·4	14·57±0·261	6·3–21·2	1·4 ±0·052	1–3	2·84±0·06	1–4
Copper ...	·001	82	**	23·68±0·867	16·8–50·4	14·16±0·289	8·4–21·2	1·24±0·043	1–2	2·64±0·077	1–4
	·0001	161	**	25·2 ±0·618	9·6–50·4	14·28±0·277	6·3–21·2	1·28±0·05	1–3	2·7 ±0·074	1–4
	·00001	223·0	*	23·00±0·747	9·8–50·4	14·28±0·295	4·82–21·2	1·4±0·054	1–3	2·98±0·062	1–5

TABLE 6—(*Contd.*)

Trace elements	Concentration in%	Mean dry weight.	Sporulation	Size of spores				Septation			
								Longitudinal		Transverse	
				Mean length	Range	Mean breadth	Range	Mean	Range	Mean	Range
Iron ...	·001	181	***	24·19±0·803	9·6–50·4	14·18±0·311	4·2–21·8	1·28±0·05	1–3	2·78±0·07	1–6
	·0001	178	***	28·14±0·984	9·6–50·4	14·6 ±0·368	4·2–25·2	1·28±0·05	1–3	2·96±0·101	1–4
	·00001	218	***	29·4 ±0·591	12·6–67·2	14·33±0·259	4·2–25·2	1·3 ±0·06	1–3	3·02±0·07	1–6
Zinc ...	·001	213	**	23·86±0·769	12·6–58·8	14·2 ±0·25	4·2–21·4	1·34±0·05	1–3	2·54±0·08	1–5
	·0001	225	***	30·49±0·748	12·6–63·0	16·00±0·225	4·2–21·4	1·46±0·05	1–3	3·00±0·08	2–5
	·00001	229	***	30·74±0·645	12·6–63·0	15·96±0·306	4·2–21·4	1·80±0·08	1–4	3·02±0·11	1–4
Iron ...	·001	229	****	26·29±0·464	12·6–63·0	14·78±0·297	4·2–21·4	1·48±0·04	1–4	2·98±0·703	1–6
+	·0001	227	****	27·72±0·822	9·6–67·2	14·87±0·275	4·2–21·4	1·72±0·07	1–4	3·0 ±0·09	1–6
Zinc ...	·00001	309	****	28·04±1·004	9·6–63·0	15·25±0·293	4·2–21·4	1·96±0·06	1–5	3·3 ±0·126	1–7
Control ...	...	151	**	24·51±0·426	8·4–42·0	13·97±0·243	4·8–21·0	1·34±0·06	1–3	2·58±0·07	1–4

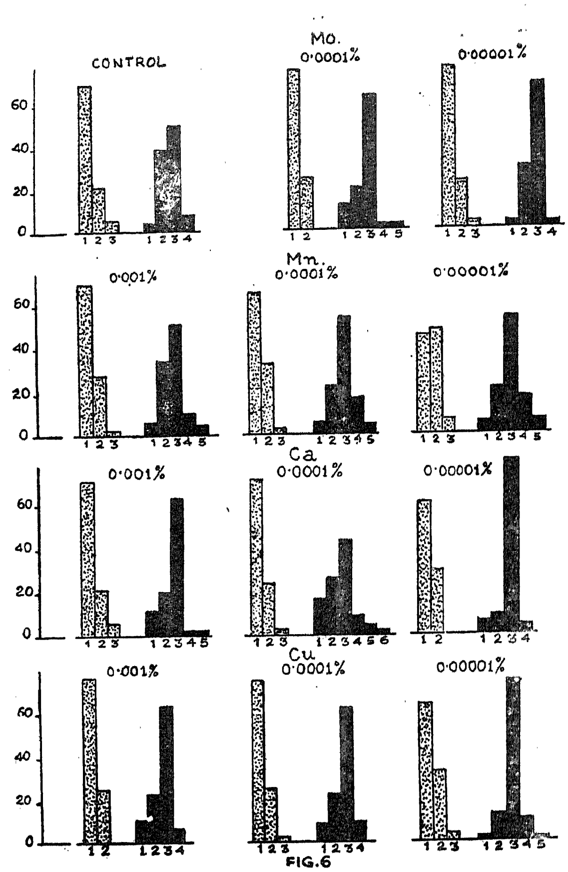


FIG.6

Frequency distributions of numbet of longitudinal and transverse septa in muriform spores taken from cultures growing on media supplemented with trace elements.

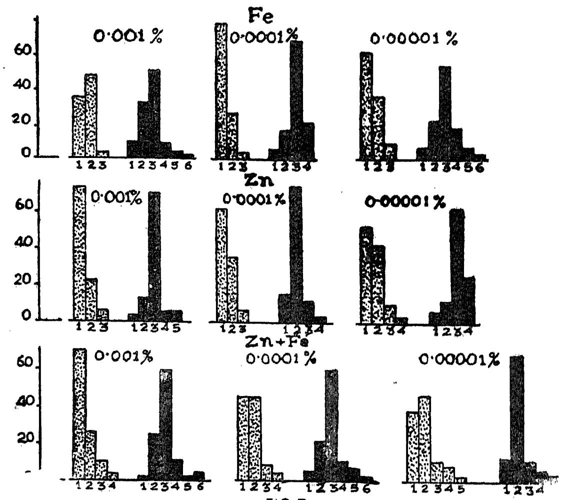


FIG.7

Frequency distributions of number of longitudinal and transverse septain muriform spores taken from cultures growing on media supplemented with trace elements.

significantly reduced. In fact the mean length as well as transverse septation was significantly greater on media which contained 0·00001% manganese or copper, 0·0001% 0·00001% iron or zinc or all the three concentrations of mixtures of iron and zinc. In addition, greater mean transverse septation was also observed on media containing 0·00001% calcium and 0·001% iron. The mean breadth was significantly greater on 0·00001% manganese; 0·0001% and 0·00001% zinc and on media containing the mixture of iron and zinc. The mean longitudinal septation was greater on the above except on 0·0001% zinc and 0·001% iron plus zinc.

The results also indicate that the size of spores and septation on manganese, copper, iron and zinc was significantly larger at lower concentrations than at higher ones (viz. 0·001%). The maximum length of muriform spores was 67·2 μ on the medium containing 0·00001% iron or 0·0001% mixture of iron and zinc. The maximum breadth was 25·2 μ on 0·0001% as well as on 0·00001% iron. The maximum number of septa (5 longitudinal and 7 transverse) were developed on the medium containing 0·00001% iron and zinc.

DISCUSSION

Alternaria tenuis exhibits a wide range of variation in the morphological characters of hyphae and spores even when it is grown on a single medium. If the nature of the latter is modified, pronounced changes may occur. For instance, the intensity of the colour of spores increased with the addition of zinc or iron. It changed from dark olive buff to buckthorn brown or dresden brown. Such striking influence of trace elements on pigmentation has also been recorded by Wolff and Emmerie (1930), Metz (1930) and Mulder (1938).

As already mentioned, *A. tenuis* is extremely polymorphous. The shape as well as size of its spores were found to vary considerably. Apart from the differences in the shape of the beaked spores some unbeaked egg shaped forms with rounded ends resembling *Pseudostemphillium* or spherical forms resembling *Eustemphyllium* were also developed.

The inclusion of maltose, larger quantities of nitrate nitrogen mixed with small amounts of ammonium nitrogen or low concentrations of some trace elements (manganese, copper, iron and zinc) induced the development of spores with larger size and with wider range of variation than those developed on the basal medium. This was particularly marked when 0·00001% iron was added to the medium. The maximum length (67·2 μ) as well as the minimum breadth (25·2 μ) were produced on it. These results confirmed the observation of Elliot (1917), Bolle (1924) and Neergard (1945) who had reported that the size of conidia was largely dependent on the culture medium. Septation also varied markedly with the nature of food material. Some substances *viz* starch and sugar alcohols among the carbon compounds and phenylalanine, tyrosine, histidine and urea among nitrogen ones adversely affected the size and septation of spores. It was observed that in general, increase or decrease in length of muriform spores was accompanied by similar changes in the number of transverse septa. Likewise, the breadth of the spores seemed to be correlated with the number of longitudinal septa. There were some instances, however, where this conclusion did not hold good. For instance, the mean length was greater but transverse septation did not increase on medium containing 5:45 of ammonium nitrogen and nitrate nitrogen. Conversely, the mean transverse septation was greater on media containing either 40 m. grams of nitrate nitrogen or 0·00001% calcium but the length did not change significantly. Similarly the mean breadth was significantly greater on media having 0·0001% zinc or 0·001% iron but longitudinal septation remained unchanged. These results suggest that

the septation was not entirely governed by the size of spores as expressed by Elliot:—" There is marked difference between the species in the number of septa. Septation is dependent upon the size of spore in a single species, but independent of the size of spore in different species." They also depend on the 'nutritive conditions.

The nature of spore wall was also found to vary considerably. It ranged from smooth walled to verrucose type with various intermediate grades. It was observed that the percentage of the latter type of spores either increases with age or with food material, e. g. iron and zinc induced wartiness, while with calcium the spores were generally smooth walled. Roberts (1924) tried to subculture separately, the two types of spores (smooth walled and verrucose) of *A. mali* (*A. tenuis*) for 22 generations but he could not succeed in establishing any definite influence of selection. It seems doubtful, therefore, that the distinction of spores in smooth walled and verrucuse types could be of taxonomic value even though Neergaard has remarked, " . . . . . . this does not rule out the possibility that the capacity for formation of echinulate verrucose conidia may be of value as a diagnostic criteria."

The present results establish that much importance should not be attached to minor differences in the characters (viz. shape, size, septation and sculpture of spore wall) for the classification of the genus *Alternaria*, because they exhibit great inconsistency as well as wide range of variations under different nutritive conditions. Grove and Skolko (1945) made numerous isolations of *A. tenuis* and (on the basis of taxonomic studies) they made similar observations. They wrote, "whereas the range in spore size is given as $20—50\mu \times 10—16\mu$, in some spores, the spores are predominently towards the upper end of the range, while in others they were predominently towards the lower. Some strains have rough spores, while others have smooth spores and in some the spores are pale olive, brown, in others dark brown. These and other characters were used as a basis for separating strains but as more cultures accumulated, it became evident that no correlation existed between the different characters." The present physiological studies have shown that under cultural conditions in the laboratory even the same strain may show a wide range of differences in its morphological characters. As such, these characters can not be used as reliable basis for taxonomic studies because in many cases the identifications are made from cultures and even under natural conditions the differences may be caused by the nature of the host tissue.

SUMMARY

The morphological and physiological studies of *Alternaria tenuis* were carried out. Its spores were found to be extremely polymorphous. Their colour, shape, size, septation and wartiness were all affected by modification of food material in the culture media. Septation was shown to be governed by the size of the spores as well as by the nutritive substances.

REFERENCES

1. Bolle, P. C. 1924 Die durch Schwarzepize (Phaeodictyae) erzeugten Pflanzenkrankheiten. Mededeel. Phytopath. Lab. Willie Commelin Scholten. 7:1—77.

2. Elliott, J. A. 1917 Taxonomic characters of the genera *Alternaria* and *Macrosporium*. Am. J. Bot. 4:439—476.

3. Groves, J. W. & Skolko, A.G. 1944 Notes on seed-borne fungi. II. *Alternaria*. Canadian Jour. Res. 22:217 234.

4. Metz, O. 1930 Ueber Wachstum und Farbstoffbildung einiger Pilze unter dem Einfluss von. Eisen, Zink, Und Kupfer Arch. Mickrobiol. 1:197-251.

5. Mulder, E. G. 1938 Sur l' influence die cuivre sur la croissance desmicroorganismes. Ann. Fermentat., 41:513-533.

6. Neergaard, P. 1945 Danish species of *Alternaria* and *Stemphyllium*. Oxford University Press.

7. Roberts, J. W. 1924 Morphological characters of *Alternaria mali*. Jour. Agri. Res. 27:699-708.

8. Steinberg, R. A. 1935 Nutritient solution purification for removal of heavy metals in deficiency investigations with *A. niger*. Jour. Agr. Res. 51:413-424.

9. Tandon, R. N. 1945 Preliminary observations on a new disease of wheat at Allahabad. Proc. National Acad. Sci (India) 1-5.

10. Wolff, L. K. & Emmerie, A. 1930 Uber das Wachstum des *Aspergillus niger* und den Kupfergehalt des Nahrbondens. Biochem. Zeitschr. 228 (4/6):443-450.

CULTURAL-CUM-MANURIAL STUDIES

ON

WEEDS OF WHEAT FIELD

By

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INTRODUCTION

Proper culture practices at sowing time and immediately after germination destroy weeds to the advantage of crop plants helping to maintain lead provided soil is supplied with essential nutrient. In order to study the effect of different levels of cultivation, manure and weeding on the number of weeds that grow in association with wheat, a factorial experiment was laid out at the Indian Agricultural Research Institute, New Delhi during the year 1951-52.

Review of Literature :

Brenchley (1915) reported that to a very great extent the mere condition of cultivation determines which plants are likely to prove troublesome as weeds. Experiments with verious crops showed that the chief benefit of tillage is the removal of competition by weeds. Cates (1912) analysed the results of 125 cultivation experiments with corn conducted in 28 different states of U. S. A. and concluded that the benificial effect of tillage was the removal of weeds. Kieselbach (1935) also showed that weed control is the main consideration in corn cultivation, while Cole (1918) investigating of the relation of weed growth to nitrates present in the soil showed that more emphasis should be placed upon the value of tillage as a weed control measure as nitrates and moisture less from the soil are chiefly through weeds. Kaul and Raheja (1952) while reviewing on weeds and their control, concluded that on arable land tillage alone or in combination with cropping often is the most economical method of weed control.

Methods and Materials :

The experiment was laid out in a split plot design with three replications. The cultivation treatments (A-3, B-6, C-9 and D-12 times ploughing) were randomised in main plots, 40 lbs nitrogen as ammonium sulphate (N_1) and no nitrogen (N_0) were assigned to sub-plots and the treatments of weeding (W_1-one weeding, W_2-Two weedings and W_0-no weeding) were randomised in Sub-sub-plots. Wheat (NP_{75}) with a seed rate of 40 seers per acre was sown on 12-11-52.

The study of weeds was conducted from 10th day after sowing in both the plots (weeding and no weeding) till the 30th day after sowing, thereafter observations were confined to only unweeded plots, for first weeding was carried out at 30th day of life cycle of the crop. One square yard areas were marked at random in the plots for studying the succession and density of weeds that came up in the wheat field.

The results of the chemical and mechanical analysis of the soil show that the soil was well drained, sandy loam and had moderate fertility. The pH of the soil was 7·5 and total soluble salts presents were 0·502%.

TABLE 1

Mechanical Analysis of the soil

Mechanical Constituents	Percentage
Coarse sand	2·96
Clay	17·25
Silt	11·50
Fine sand	64·95

TABLE 2

Chemical Analysis of the soil

Constituents	Percentage on air dry basis	Percentage on oven dry basis
	in concentrated Hcl extract	
Moisture	1·36	
Loss in ignition	2·05	
Hcl in solubles	94·48	
CaO	0·67	0·68
MgO	0·34	0·34
K_2O	0·483	0·49
P_2O_5	0·064	0·065

Total N on air dry basis—0·039%

EXPERIMENTAL RESULTS AND DISCUSSION

Sequence of appearance of different weeds :

The order of sequence of different species of weeds and the days taken by the individual species to mature is given in the following table, from which it is seen that *Chenopodium album* took the longest to mature (production of seed) (161 days) whereas *Spergula arvensis* completed its life cycle in only 72 days (the least time taken to mature). Some of the weeds viz. *Launaea asplenifolia, Fumaria parviflora* and *Cyperus rotundus* did not either flower or mature during the crop season,

TABLE 3

Time of appearance, maturity and duration of life cycle of weeds of wheat field

Weed plants	Appeared on	Matured on	Duration of life cycle
1. Cynodon dactylon (Dub)*	12th November	...	...
2. Cyperus rotundus (Motha)*	13th November	...	...
3. Asphodelus tenuifolius (Piazi)	14th November	1st April	156 days
4. Chenopodium album (Bathua)†	15th November	25th April	161 days
5. Pluchea lanceolata (Bainsuri)	17th November	15th April	153 days
6. Melilotus indica (Senji)	20th November	18th February	100 days
7. Fumaria parviflora (Gajra)‡	1st December	...	...
8. Spergula arvensis (Ath gathia)	3rd December	12th February	72 days
9. Argemone maxicana (Katila)	4th December	10th May	157 days
10. Launaea asplenifolia (Jangli Gobhi)	9th December	28th April	140 days
11. Lathyrus sativus (Matri)	17th December	10th May	144 days
12. Vicia hirsuta (Mun Muna)	19th December	12th April	114 days
13. Anagallis arvensis (Krishan Nil)	4th January	8th April	94 days
14. Phyllanthus niruri (Hazardana)	5th January	25th April	110 days

Proportion of total and individual weeds.

These data are arranged in Table 2 and are grouped under each cultivation treatment. The percentage of weeds in the population was calculated for each observation.

The germination of wheat seeds began from the sixth day and reached the maximum between the 12th and 14th day (Table 4). The weed *Cynodon dactylon* and *Cyperus rotundus* made its appearance before the wheat and was the predominant weed among the weed population during the period of germination of wheat. On the 6th day of germination the percantage of these weeds was as high as 18·5 which went on decreasing till the 8th day. During this interval these weeds increased but slightly and the decrease in the percantage in the total population was due to the tremendous increase in the seedlings of wheat (Table 4). *The germinating wheat therefore completely covered up early weed population that had come up, being evidently due to the high proportion of seeds of the crops.* This lends support to the view held by Pavlychenko (1934) that the crop can be made to smother the weeds by higher seed rate. After the 8th day of germination the percentage of weeds steadily increased till the weeds far exceeded the wheat plants in the population. This can be seen from table 4 is due to the decrease in the number of wheat plants (surviving ones from among the seedlings) and a progressive increase in the number of weeds. The increase in the number of weeds is due to the appearance and

* These weeds did not flower during the crop season.
† Persisted till about the harvest of the crop.
‡ These weeds flowered but did not mature during the crop season.

pre-ponderance which come up later. While *Cyperus rotundus* was the dominant weed till about the 8th day, *Chenopodium album* was most dominant on the 12th day to be superseded by *Melilotus indica* about the 14th and 30th day (Table 5).

It is evident from Table 3 that in the population of weeds *Cyperus rotundus*, *Chenopodium album* and *Melilotus indica* held the dominant position throughout the major part of the life cycle, of wheat crop, in comparison with other eleven species of weeds that appeared in small numbers during this stages of the life cycle of the crop.

Due to the poor germination and consequently poor stand of the crop under the treatment A and B, the wheat crop was more in association with weed population in these treatments as compared to the wheat crop under the treatments C and D, (Table 4 and 5).

TABLE 4

Weed crop competition

	A				B			
Days after sowing	Total wheat & weed population	Wheat	Weed	% of weeds to total population	Total wheat & weed population	Wheat	Weed	% of weeds to total population
6	91·35	74·45	* (16·90	18·50	86·14	73·40	* (12·64	14·70
8	130·84	107·02	(23·83	18·21	110·12	99·31	(10·80	9·81
10	122·60	95·19	† (27·42	22·36	118·76	103·92	† (14·84	12·50
12	138·58	106·82	(31·77	22·92	144·77	122·25	(22·52	15·55
14	165·31	117·53	$ (47·78	28·73	161·02	119·24	$ (41·78	25·95
30	146·29	101·42	(44·87	30·67	151·42	117·04	(34·37	22·70
	C				D			
6	96·08	88·74	* (7·34	7·64	101·14	93·80	* (7·34	7·26
8	127·71	111·11	(16·60	13·00	128·20	115·77	(12·43	9·63
10	128·43	110·46	† (17·97	14·00	127·40	113·88	† (13·52	10·61
12	149·43	130·23	(19·20	12·85	158·18	127·07	(31·11	19·67
14	158·60	119·99	$ (38·62	24·35	184·92	144·33	$ (40·59	21·95
30	165·54	126·76	(38·78	23·43	150·87	119·82	(31·50	20·58

N. B. The figures are average of 3 one square yard random samples, Bracketed portions indicate the dominance of the particular weed marked against them.

Legend * (Motha) *Cyperous rotundus.* † (Bathua) *Chenopodium album.* $ (Senji) *Melilotu sindica.*

TABLE 5

Crop-weed ratio at 30th day of the life cycle of wheat Under the cultivation treatments

	Weed species	A	B	C	D
1.	Cynodon dectylon	2·85	2·15	...	...
2.	Cyperus rotundus	4·15	2·55	0·55	Nil
3.	Asphodelus tenuifolius	3·55	3·95	4·55	2 5
4.	Chenopedium album	5·02	7·95	5·68	7·45
5.	Pluchea lanceolata	0·45	...	...	...
6.	Melilotus indica	18·90	10·45	20·98	19·56
7.	Fumaria parviflora	3·41	2·45	1·96	0·5
8.	Spergula arvensis	1·10	0·95	...	...
9.	Argemons maxicana	3·00	1·90	...	...
10.	Launaea aspleniifolia	0·55	...	...	...
11.	Lathyrus sativua	0·95	0·85	2·1	0·55
12.	Vicia hirsuta	0·85	0·50	0·89	...
13.	Anagallis arvcnsis	0·75	...	0·11	...
14.	Phyllanthus niruri	0·45	1·50	...	...
	Wheat	101·41	117·04	126·75	119·82

Weed population at successive stages of the life cycle under high and low fa,ming conditions:

It is interesting to note that the weed population was different under different treatments (Table 5). Intensive ploughings (B,C & D) exhibited less number of weeds associated with the crop as compared to the crop under less number of cultivations (A). Weed population was also less under fertilized plots as compared to the control. This lends support to the view held by keen (1938) that intensive cultivation help to control weeds. These results show that better farming practices result into better stand of the crop which no doubt has smothering effect that reduces weed population.

TABLE 6

Effect of frequency of cultivation and nitrogen on weed population

Days after sowing	A	B	C	D	No	N1
6	16·9	12·6	7·3	7·3	14·4	11·6
8	23·8	10·8	16·5	12·4	20·3	14·4
10	27·4	14·8	17·9	13·5	24·1	18·6
12	31·7	22·5	19·1	31·1	30·6	27·9
14	47·7	41·7	33·6	40·5	39·4	35·5
30	44·8	34·5	38·7	31·0	35·9	28·0

Amount of nitrogen removed by different weeds at 60th day of the life cycle :

The nitrogen analysis of the shoot and root portion of some of the important weeds was done in order to have an idea of the magnitude of loss of nitrogen due to individual weed speices. The data is presented in Table 7 :

TABLE 7

Amount of nitrogen removed by different weeds at the 60th day of the life cycle

(Percentage)

(On dry matter basis)

Weed species	Shoot	Root
1. Chenopodium album	6·72	1·09
2. Melilotus indica	9·5	1·72
3. Argemone maxicana	0·93	1·24
4. Fumaria parviflora	2.99	...
5. Anagallis arvensis	3·22	1·50
6. Convolvulus arvensis	1·84	0·61
7. Cilicia Spp	1·71	...
8. Asphodelus tenuifolius	1·94	
9. (Ath gathia) Spergula arvensis	2·4	

From the above table it will be seen that weeds remove a high proportion of nitrogen from the soil; out of the nine weed species listed above *Melilotus indica* removed a failry high portion of soil nitrogen followed by *Chenopodium album*, *Anagallis arvensis*, and *Fumaria parviflra*, the rest do not remove so much nitrogen from the soil.

The root and shoot portion of the weed species was analysed with a view to have an idea of the amount of nitrogen actually removed by different weed species as the nitrogen contained in the root cannot be said to have been removed by weeds as only the shoot portion of weeds is removed during the operation of weeding and the root portion is left in the soil, which ultimately decompose and give back the nitrogen contained in it to the soil. Nevertheless, weeds remove a fair amount of nitrogen from the soil which in the absence of them would have been retained in the soil and consequently helped in the building up of soil fertility.

Effect of weeding on the grain yield

The following table contains the yield of grain per acre in mds. as affected by different levels of weeding :

TABLE 8

Effect of weeding on grain yield

Sub-sub plot treatment	Mean yield: in mds. per acre*		Mean yield: Increase (% of W_0)
W_0	6·0		...
W_1	8·3		38·1
W_2	7·6		26·8
C. D.	0·3	(5%)	Result $W_1 > W_2 > W_0$ (1%)
	0·4	(1%)	

The result in table 8 show that highest grain yield was obtained under W_1. This yield (8·3 mds. per acre) was significantly higher than the yield obtained under W_2 (7·6 mds./acre) and W_0 (6·0 mds./acre). It is evident that one weeding over no weeding has given a response of 2·3 mds. grain yield per acre. After one weeding there was no response to the 2nd weeding. Contrarily a decrease of 0·1 mds. of grain per acre was noted. This can be explained on the basis that the 2nd weeding W_2 was done at the stage (end of Janurary) when the crop was sufficiently dense and vigourous and the stage of severe competition between crop and weed was almost over. Weeding at this stage, therefore, instead of doing any good to the crop seemed to have injured the roots of the crop plants resulting into a lower growth attributes and finally the yield. This result was in conformity with the findings of keen (1942), Rosenfield (1946), and wilcox (1948**) who concluded that any cultivation in excess over the optimum may prove harmful so far as the crop yields are concerned.

Acknowledgement :

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BIBLIOGRAPHY

Brenchley, Ewinfread	1915	*Jour. Roy. Agric. Soc. England* 76.
Cates, J. S. & H. R. Cox	1912	*U. S. Dept. Agric. Bur. Plant. Ind. Bull* 2507.
Cole, R. C. *	1939	*Hilgardia*, 12 (6) : 429-70.
Dutt N. L. **	1946	Report on the survey of Sugarcane Research in India for the I. C. A. R.
Kaul R. N. & P. C. Raheja	1952	*Sci. & Culture* 18 ; 124-129.
Kieselback, T. A., *et al*	1935	*Hebr. Agri. Expt. Sta. Bull* 293 : 1-20.
Keen, B. A.	1942	*Jour. Roy. Soc. Arts.* 90 : 545-79.
Keen B. A.	1936	*Jour. Ministry of Agri.* 45 : 645-52.
Keen B. A.	1942	*Proc. Royal. Soc. Arts.*
Pavlychenko, T. K. et al, Canad	1934	*Jour. Res.* 10 : 77-94.

* Lower yield figures are due to complete breaking down of the crop plants by severe hailstorm at milky stage of the crop.

THE EFFECT OF CLIPPING OF SHOOT TIPS ON NODULATION IN *CICER ARIETINUM*

By

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INTRODUCTORY

Clipping of young buds and green foliage of *Cicer arietinum* during early vegetative growth for supplying leafy and green vegetables is a common practice. The practice is recognised as one of very great advantage to the improved bushy vegetative growth, and is presumed to give better seed yields. Yet the sanction behind such an age-long practice is not known. The plea that any practice may be developed through method of trial and error, and in cases, these may be declared sound, is hardly sufficient excuse in not determining its scientific basis. The significance of clipping of the tender top foliage in gram on root nodulation and seed yield of gram have been studied and reported in this communication.

METHODS AND MATERIALS

Variation in the degree of clipping was introduced by the inclusion of one or more branches whose top young foliage was clipped a month (after germination. Clipping of shoot tips of *Cicer arietinum* of about 1·5 in. from the top was done in four grades; NC, C_1, C_2, and C_4, where the shoot tips of none, one, two, or four branches, respectively, were removed.

Average of six replicates have been employed to represent the treatment effects. Standard error and critical difference due to clipping treatments have been worked out and shown as S. E. and C. D. for all the characters reported.

EXPERIMENTAL RESULTS

Linear Growth

Different degrees of clipping influenced linear growth favourably upto a certain limit only (Table 1).

TABLE 1.

Effect of Clipping on Foliar Growth of *Cicer Arietinum*
(Cm., length main shoot)

Age (weeks)	Degree of Clipping			
	NC	C_1	C_2	C_4
7	17·00	19·54	20·28	16·78
9	18·18	24·26	21·30	17·61
11	23·05	27·18	25·32	19·36
13	30·17	30·42	36·07	30·19
15	36·46	35·27	45·46	32·24
17	36·27	37·92	46·20	32·27
Mean	26·855	29·093	32·439	24·741

S. E. = 1·065 C. D. = 3·2091

Clipping of two shoots (C_2) significantly increased the growth of tops, while severe clipping (C_4) proved detrimental as compared to control, though insignificant ly. Between C_1 and C_4 significant depressive effect of C_4 was apparent. Shoot length increased with age, under all grades of clipping.

Dry Matter Accumulation

Growth of tops, judged by dry matter accumulation in shoot, was increased by C_2 and C_1, though significantly only in the latter case (Table 2). C_4 reduced shoot weight though insignificantly.

TABLE 2

Effect of Clipping on Dry Matter Accumulation in Tops of *Cicer Arietinum*

(Gm., tops/plant)

Age (weeks)	Degree of Clipping			
	NC	C_1	C_2	C_4
7	0·56	0·97	1·07	1·03
9	0·97	1·15	1·14	1·12
11	1·09	1·37	1·62	1·40
13	2·61	3·42	3·34	2·53
15	7·22	8·14	10·26	6·86
17	7·51	7·46	10·00	6·36
Mean	3·360	3·751	4·571	3·216

S. E. = 0·3038 C. D. = 0·9154

TABLE 3

Effect of Clipping on Dry Matter Accumulation in Roots of *Cicer Arietinum*

(Gm., Roots/plant)

Age (weeks)	Degree of Clipping			
	NC	C_1	C_2	C_4
7	1·44	1·43	0·96	1·62
9	1·53	1·62	1·00	1·64
11	1·64	1·92	1·16	2·02
13	2·01	1·74	1·35	2·43
15	2·29	1·55	1·75	2·52
17	1·82	1·54	1·75	1·86
Mean	1·790	1·633	1·323	2·015

S. E. = 0·091 C. D. = 0·2745

Root growth was significantly highest in C_4 (Table 3). Clipping of either one shoot tip or two, lowered root weight. With advance in the age of the plant, root weight increased upto the fifteenth week afterwards a decline was noted.

Shoot-root Ratio

Clipping of two shoot tips produced maximum shoot-root ratio followed by clipping one tip, no clipping and clipping of four tips (Table 4). Of C_2 and C_1 the former induced a higher ratio, though the difference just missed the level of significance. C_4 significantly reduced the ratio as compared to C_1 and C_2 but as against control, the difference was not significant. C_2 alone increased the ratio significantly.

TABLE 4

Effect of Clipping on the Ratio of Dry Matter Accumulation in Tops and Roots of *Cicer Arietinum*

Age (weeks)	Degree of Clipping			
	NC	C_1	C_2	C_4
7	0·381	0·67	1·11	0·63
9	0·630	0·70	1·14	0·68
11	0 660	0·71	1·39	0·69
13	1·370	1·96	2·47	1·04
15	3·150	5·25	5·86	2·72
17	4·120	4·84	5·81	3·41
Mean	1·755	2·351	2·963	1·530

S. E. = 0·2276 C. D. = 0·6858

Nodular Infection

Clipping two tips significantly reduced number of root nodules over other treatments (Table 5). NC, C_4 and C_1 had for their roots 69, 68 and 61 nodules per plant, on an average; the depressive effect was visible even though the differences were not significant. The general trend of the results appeared to be that light and severe clippings (C_1 and C_4 respectively) did not prove significantly detrimental in nodule formation, while moderate clipping (C_2) did so.

Effect of Clipping on Nodulation in *Cicer Arietinum*

Table 5. Numerical count per plant

Age (weeks)	Degree of Clipping			
	NC	C_1	C_2	C_4
7	28·6	26·3	22·7	27·1
9	43·9	41·8	38·0	42·2
11	64·4	63·4	46·5	69·3
13	93·5	77·7	64·7	84·6
15	107·2	85·8	51·7	107·7
17	76·9	75·9	42·6	77·4
Mean	69·91	61·50	44·36	68·05

S. E. = 3·875 C. D. = 11·6672

Table 5*a*. Gm., oven dry nodules/plant

7	0·082	0·065	0·032	0·085
9	0·121	0·117	0·115	0·123
11	0·180	0·145	0·127	0·182
13	0·221	0·160	0·134	0·305
15	0·227	0·162	0·143	0·316
17	0·223	0·160	0·130	0·312
Mean	0·1757	0·1350	0·1135	0·2205

S. E. = 0·01414 C. D. = 0·04261

Nodular Mass

Nodule development was significantly increased with four clippings but was reduced with two (Table 5*a*). Nodular mass was more with no clipping (NC) as

against single clipping, though the difference just missed the level of significance. Severe clipping (C_4) reduced the shoot-nodule ratio, on dry matter basis, from 9·12 (for control) to 14·58; one and two clippings increased it to 27·28 and 40·27 respectively. This suggested that with the onset of conditions suited for prolific vegetative growth nodulation, in legumes, was diminished.

Grain Yield

Clipping to the extent of two shoots was significantly superior over other treatments in increased yield of grain (Table 6).

TABLE 6

Effect of Clipping on Seed Yield

(Gm., per gram plant)

Replicates	Degree of Clipping			
	NC	C_1	C_2	C_4
I	6·56	7·48	9·20	5·45
II	6·69	7·50	9·15	5·42
III	6·57	7·46	9·00	5·47
IV	6·59	7·52	9·18	5·40
V	6·55	7·45	9·26	5·42
VI	6·69	7·45	9·12	5·40
Mean	6·610	7·491	9·151	5·426

S. E. = 0·0264 C. D. = 0·0795

Severe clipping to the extent of four shoot tips reduced the yield significantly as against control. Thus while moderate clipping may prove advantageous in agronomic practice in improving yield, severe clipping should be avoided. It is not quite right to maintain that all grades of gram clipping, as is at present widely practiced, would result in enhanced yields.

DISCUSSION

Plant carbohydrate was shown to have indirect influence on nodulation (Singh, 1957, 1958). Clipping of the shoot tips was shown to affect nodulation possibly due to a disturbance in the carbohydrate-nitrogen balance. Moderate clippings proved significantly detrimental in nodule formation while severe clippings increased nodule develoment significantly. Severe clipping reduced shoot-root ratio while lighter ones appreciably increased it. Full utilisation of carbohydrate favouring vegetative growth was shown to be detrimental for nodulation possibly due to decreased supply of energy to bacteria inhabiting root nodules.

Marked decrease in storage reserves of roots due to severe cutting of tops as reported by Sturkie (1930), Thoronton and Nicol (1934), Grandfield (1935) and others may also be the factor in decrease of nodulation. Thoronton and Nicol (1934) further reported that the clipping of alfalfa did not significantly alter the number of nodules on the roots. The variance in the present findings and that of Thoronton and coworker may be attributed to the fact that the behaviour of forage legume and seed legume with respect to nodulation were dissimilar (Singh, 1958). This may also be due to the difference in environmental conditions of the two investigations carried out in differing latitudes. Leonard (1926) reported that when the amount of photosynthate was decreased by the growing of plants during short days, by clipping them, or by growing them in an atmosphere low in carbon-di-oxide, there was poor nodule development than when photosynthesis was not decreased.

Howard and Howard (1917), working with indigo, reported that heavy prunning of the first crop of indigo leaving a few leaves resulted in far less damage to the roots and nodules and a more rapid development of the second crop than persuing the common practice of completely cutting back the first growth. This signified that in the case of legumes the extent of prunning or clipping was a factor that controlled its own growth and development and also nodulation through the adjustment of the carbohydrate-nitrogen ratio. The cutting or clipping practice was thus, advantageous in not only giving more returns of seed but also of fundamental value in increasing soil fertility provided the degree and the time of clipping was, properly adjusted in accordance with the C/N status of the plant. Comparatively few communications concerned with factors that affect the amount of carbohydrate manufactured by the plant in the process of photosynthesis and its effect on nodule production and development are met with.

SUMMARY

Replicated field trials were conducted to determine the scientific basis of the age-long practice of clipping of shoot tips of *Cicer arietinum*.

Moderate clippings of shoot tips, proved beneficial for growth as well as seed yield of gram while the heavier ones significantly more conducive to root growth and nodulation.

BIBLIOGRAPHY

1. Grandfield, C. O. 1935 *J. Agr. Res.*, 50, 697-710.
2. Howard, A and Howard, G. L C. 1917 *Agr. Jour. India*, Indian Science Congress number.
3. Leonard, L. T. 1926 *Jour. Amer. Soc. Agron.*, 18, 1012-1016.
4. Singh, A. 1957 *Proc. Nat. Acad. Sci. India, 27B*, Part IV, 180-195.
5. Singh, A. 1958 *Symp. Rec. Adv. Pl. Metabolism, Allahabad University.*
6. Sturkie, D. G. 1930 cf. Russell, E. J., Soil Conditions and Plant Growth, 1950.
7. Thoronton and Nicol 1934 *Jour. Agr. Sci.* 24, 532-539.

A REVISION OF INDIAN STRIGEIDA.

PART I

REDESCRIPTION AND TAXONOMIC POSITION OF *NEODIPLOSTOMUM GAVIALIS* NARAIN, 1930

By

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Received on 8th February 1958

Narain (1930) described a strigeid parasite obtained from one out of eleven specimens of the Indian Crocodile, *Gavialis gangeticus*, examined by him at different times. He assigned this form under the genus *Neodiplostomum* Railliet, 1919 of the subfamily Polycotylinae Monticelli, 1888 (Family Strigeidae Railliet, 1919) following La Rue's (1926) classification. A revolutionary change has since been made in the classification of Strigeids through valuable researches of numerous Helminthologists and through the monographic works of Dr. Georges Dubois of Neuchatel (Switzerland). The genus *Neodiplostomum* Railliet, 1919 and the subfamily Polycotylinae Monticelli, 1888, according to the present classification, belong to different strigeid families viz., Diplostomatidae Poirier, 1886 and Proterodiplostomatidae Dubois, 1936 respectively. These two families are distinguished from each other chiefly by the presence of a paraprostate in the latter family and its absence in the former. Since Narain's ≮ *Neodiplostomum gavialis* ≯ is characterised by the presence of a paraprostate and since the vitelline follicles in it are limited to the anterior segment of its body only, Dubois (1938) assigned this form under the family Proterodiplostomatidae and its subfamily Polycotylinae but its definite generic assignation within this subfamily is still undecided and Dubois has always (1938, 1953) kept it as a *species inquirenda*. Such a state of affairs is almost entirely due to the fact that in Narain's description of this form, the details of the association of genital ducts and paraprostate and the structure of the copulatory bursa are not given to the extent they are needed for deciding its correct taxonomic position.

I, in the year 1956, had the occasion of examining a specimen of *Gavialis gangeticus*, shot by a friend on the banks of The Ganges near Anupshahr in U. P. 27 specimens of the strigeid form which is presently under consideration were obtained from the intestine of this Crocodile. I, therefore, take this opportunity to give a detailed redescription of this form and to discuss its taxonomic position.

Neelydiplostomum gavialis (Narain, 1930) nov. comb.

The total length of the body of this strigeid is 3·229—4·0 mm., with a maximum breadth of 0·861—1·01 mm., occurring slightly behind the equatorial level. The bisegmentation of the body is morphologically distinct. The anterior segment is elongated leaflike with a slight constriction at about its middle, and with its posterior half being more or less barrel-shaped having the maximum breadth of the body at about its middle. The anterior half of this segment is subfusiform and

Marked decrease in storage reserves of roots due to severe cutting of tops as reported by Sturkie (1930), Thoronton and Nicol (1934), Grandfield (1935) and others may also be the factor in decrease of nodulation. Thoronton and Nicol (1934) further reported that the clipping of alfalfa did not significantly alter the number of nodules on the roots. The variance in the present findings and that of Thoronton and coworker may be attributed to the fact that the behaviour of forage legume and seed legume with respect to nodulation were dissimilar (Singh, 1958). This may also be due to the difference in environmental conditions of the two investigations carried out in differing latitudes. Leonard (1926) reported that when the amount of photosynthate was decreased by the growing of plants during short days, by clipping them, or by growing them in an atmosphere low in carbon-di-oxide, there was poor nodule development than when photosynthesis was not decreased.

Howard and Howard (1917), working with indigo, reported that heavy prunning of the first crop of indigo leaving a few leaves resulted in far less damage to the roots and nodules and a more rapid development of the second crop than persuing the common practice of completely cutting back the first growth. This signified that in the case of legumes the extent of prunning or clipping was a factor that controlled its own growth and development and also nodulation through the adjustment of the carbohydrate-nitrogen ratio. The cutting or clipping practice was thus, advantageous in not only giving more returns of seed but also of fundamental value in increasing soil fertility provided the degree and the time of clipping was, properly adjusted in accordance with the C/N status of the plant. Comparatively few communications concerned with factors that affect the amount of carbohydrate manufactured by the plant in the process of photosynthesis and its effect on nodule production and development are met with.

SUMMARY

Replicated field trials were conducted to determine the scientific basis of the age-long practice of clipping of shoot tips of *Cicer arietinum*.

Moderate clippings of shoot tips, proved beneficial for growth as well as seed yield of gram while the heavier ones significantly more conducive to root growth and nodulation.

BIBLIOGRAPHY

1. Grandfield, C. O. 1935 *J. Agr. Res.*, 50, 697-710.
2. Howard, A and Howard, G. L. C. 1917 *Agr. Jour. India*, Indian Science Congress number.
3. Leonard, L. T. 1926 *Jour. Amer. Soc. Agron.*, 18, 1012-1016.
4. Singh, A. 1957 *Proc. Nat. Acad. Sci. India, 27B*, Part IV, 180-195.
5. Singh, A. 1958 *Symp. Rec. Adv. Pl. Metabolism, Allahabad University.*
6. Sturkie, D. G. 1930 cf. Russell, E. J., Soil Conditions and Plant Growth, 1950.
7. Thoronton and Nicol 1934 *Jour. Agr. Sci.* 24, 532-539.

A REVISION OF INDIAN STRIGEIDA.

PART I

REDESCRIPTION AND TAXONOMIC POSITION OF *NEODIPLOSTOMUM GAVIALIS* NARAIN, 1930

By

RAMESH GUPTA

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Received on 8th February 1958

Narain (1930) described a strigeid parasite obtained from one out of eleven specimens of the Indian Crocodile, *Gavialis gangeticus*, examined by him at different times. He assigned this form under the genus *Neodiplostomum* Railliet, 1919 of the subfamily Polycotylinae Monticelli, 1888 (Family Strigeidae Railliet, 1919) following La Rue's (1926) classification. A revolutionary change has since been made in the classification of Strigeids through valuable researches of numerous Helminthologists and through the monographic works of Dr. Georges Dubois of Neuchatel (Switzerland). The genus *Neodiplostomum* Railliet, 1919 and the subfamily Polycotylinae Monticelli, 1888, according to the present classification, belong to different strigeid families viz., Diplostomatidae Poirier, 1886 and Proterodiplostomatidae Dubois, 1936 respectively. These two families are distinguished from each other chiefly by the presence of a paraprostate in the latter family and its absence in the former. Since Narain's « *Neodiplostomum gavialis* » is characterised by the presence of a paraprostate and since the vitelline follicles in it are limited to the anterior segment of its body only, Dubois (1938) assigned this form under the family Proterodiplostomatidae and its subfamily Polycotylinae but its definite generic assignation within this subfamily is still undecided and Dubois has always (1938, 1953) kept it as a *species inquirenda*. Such a state of affairs is almost entirely due to the fact that in Narain's description of this form, the details of the association of genital ducts and paraprostate and the structure of the copulatory bursa are not given to the extent they are needed for deciding its correct taxonomic position.

I, in the year 1956, had the occasion of examining a specimen of *Gavialis gangeticus*, shot by a friend on the banks of The Ganges near Anupshahr in U. P. 27 specimens of the strigeid form which is presently under consideration were obtained from the intestine of this Crocodile. I, therefore, take this opportunity to give a detailed redescription of this form and to discuss its taxonomic position.

Neelydiplostomum gavialis (Narain, 1930) nov. comb.

The total length of the body of this strigeid is 3·229—4·0 mm., with a maximum breadth of 0·861—1·01 mm., occurring slightly behind the equatorial level. The bisegmentation of the body is morphologically distinct. The anterior segment is elongated leaflike with a slight constriction at about its middle, and with its posterior half being more or less barrel-shaped having the maximum breadth of the body at about its middle. The anterior half of this segment is subfusiform and

terminates into the bluntly pointed anterior body end. The total length of this segment is 2·316—2·782 mm.* The posterior segment is almost cylindrical, but a bit broader in its middle. It is considerably smaller than the anterior segment being 0·913—1·218 mm. in length and 0·561—0·775 mm. in maximum breadth. It terminates posteriorly into the broadly rounded posterior body end while anteriorly it is slightly but distinctly constricted off from the anterior segment.

The suckers are moderately well-developed. The oral sucker is terminal, oval in shape and measures 0·049—0·053 mm. in length and 0·045—0·056 mm. in breadth. The ventral sucker is situated at about the middle of anterior segment. It is subspherical in shape and is considerably larger than the oral sucker measuring 0·138—0·157 mm. in length and 0·126—0·143 mm. in breadth. A little behind the ventral sucker is a large, longitudinally oblong ventral holdfast organ (tribocytic organ) occupying about 2/3 length of the posterior half of anterior segment. It is 0·778—0·86 mm. in length and 0·337—0·475 mm. in maximum breadth. It bears about 70—100 small papillae on its margins. Several prominent adhesive glands are present in the region of posterior part of the holdfast organ.

The terminal mouth leads into a very short prepharynx which can be easily seen only in sections. The pharynx is quite prominent and muscular. It is elliptical in shape and measures 0·058—0·07 mm. in length and 0·038—0·041 mm. in breadth. Leading from the pharynx is a short oesophagus which bifurcates into two intestinal caeca. The latter are narrower in the anterior half of anterior segment but in the rest of their course they become sinuous. Immediately behind the holdfast organ they become somewhat arcuate and then extend posteriorly upto the vescicula seminalis. In the posterior half of the anterior segment, the caecal walls are prominently crenulated. A brownish granular substance can be seen in the distal parts of the caeca.

The male genital organs consist of two large testes occupying a large part of the anterior half of posterior body segment. The abnormal presence of a single testis in place of the usual two, as mentioned by Narain (1930) has also been found in one specimen of my collection. Both the testes are somewhat transversely stretched and are situated obliquely one behind the other, the anterior testis being slightly displaced towards the left of the median line. The anterior testis is invariably smaller in size measuring 0·18—0·262 mm. in length and 0·329—0·4 mm. in breadth. The posterior testis, on the other hand, measures 0·23—0·3 mm. in length and 0·33—0·412 mm. in breadth. From the right latero-anterior border of the posterior testis its vas eferens arises, runs forwards and bends horizontally inwards at ovarian level. At about the median line it is joined by the vas eferens of anterior testis which arises from the left latero-anterior border of this testis. The common vas deferens extends slightly in front of the ovary and is then reflexed and continued back submedially and dorsally, upto the post-testicular region. Just behind the posterior testis, it becomes swollen to form a coiled vescicula seminalis which continues back as a short narrow ejaculatory duct which opens into the proximal bulb-like part of a weakly muscular and flask-shaped paraprostate which is 0·215—0·3 mm. long. This bulb-like part of the paraprostate is surrounded with numerous small unicellular prostate gland cells. The distal narrow duct-like part of the paraprostate passes through the substance of a prominent, muscular and V-shaped genital cone measuring 0·145—0·178 mm. in length and then opens at its summit into the copulatory bursa. The latter is very muscular and quandrangular in shape measuring 0·268—0·31 mm. in length and 0·31—0·36 mm. in breadth, thus occupying approximately the last quarter of the posterior body segment. An additional

*The length of anterior segment given as 1·8 mm., by Narain seems to be a printing mistake for 2·8 mm.

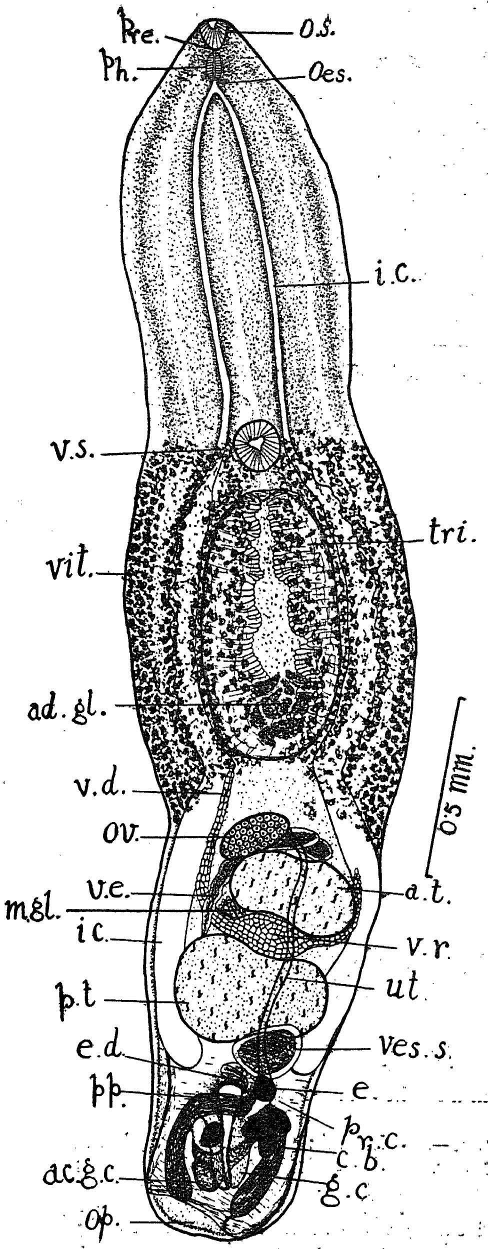

Fig. 1. Ventral view of *Neelydiplostomum gavialis.*

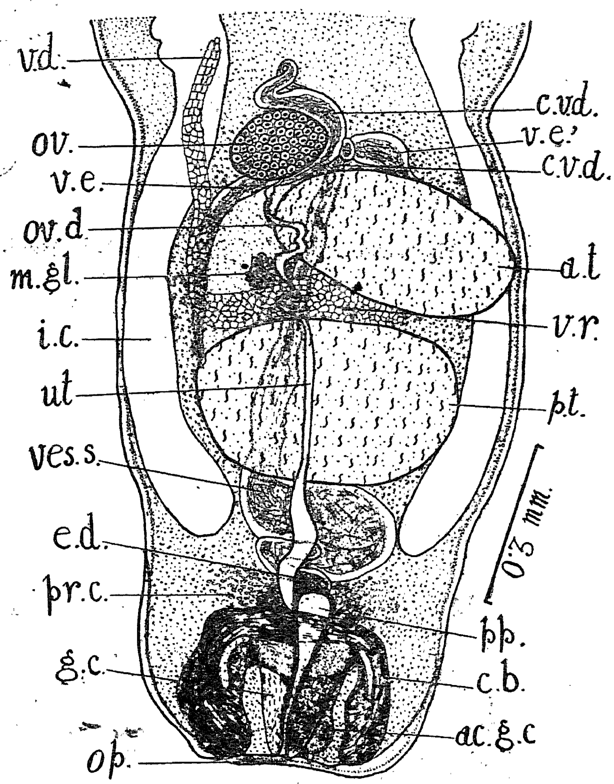

Fig. 2.

Fig. 2. Ventral view of posterior segment of *N. gavialis.*

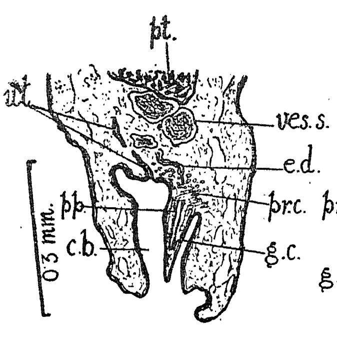

Fig. 3

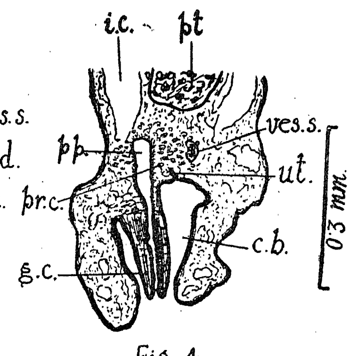

Fig. 4.

Fig. 3. and 4. Saggital sections of posterior part from the series of one specimen.

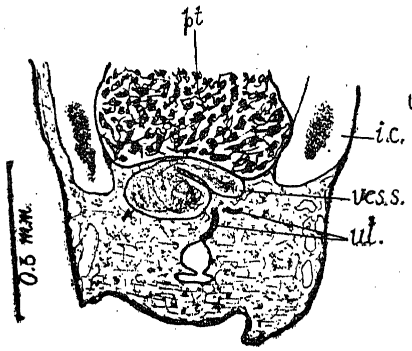

Fig. 5.

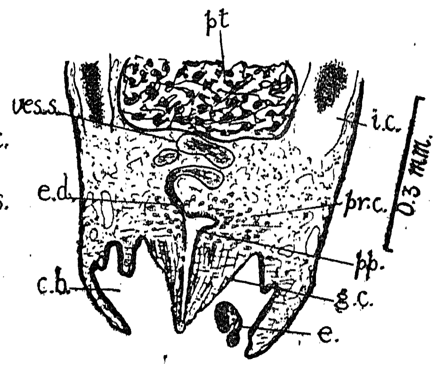

Fig. 6.

Fig. 5. and 6. Saggital sections of posterior part from the series of another specimen.

ac. g. c.—accessory genital cone; ad. gl.—adhesive glands; a. t.—anterior testis; c. b.—copulatory bursa; c. v. d.—common vas deferens; e —egg; e. d.—ejaculatory duct; g. c.—genital cone; i. c.—intestinal caecum; m. gl —Mehli's glands; oes.—oesophagus; op.—opening of copulatory bursa; o. s.—oral sucker; ov.—ovary; ov. d.—oviduct; ph.—pharynx; pp.—paraprostate; pre.—prepharynx; pr. c.—prostatic gland cells; p. t. posterior testis; tri.—tribocytic organ; ut.—uterus; v. d.—longitudinal vitelline duct; v. e.—vas eferens of posterior testis; v.e.—vas eferens of anterior testis; ves. s.—vescicula seminalis; vit.—vitelline follicles; v. r.—vitelline reservoir; v. s.—ventral sucker.

cone-like structure measuring 0·126—0·156 mm. in length arises from the antero-ventral wall of the copulatory bursa at about the base of the true genital cone. The distal part of this structure is swollen like a prepuce and is markedly constricted off from the proximal part. I prefer to call this structure as an accessory genital cone which though has no connection with the genital ducts, but whose function as an accessory cone during copulation is quite apparent.

The female organs consist of a single ovary situated between the two body segments immediately in front of the anterior testis but somewhat obliquely to it since it is slightly displaced towards the right of the median line of body. It is transversely oval or elliptical in shape but instead of being horizontal, its transverse axis is slightly oblique to that of the body. In size, the ovary is 0·115—0·131 mm. in length and 0·146—0·177 mm. in breadth. A narrow oviduct arises from one side of the ovary and runs backwards upto the intertesticular region where it terminates into the Mehli's gland complex. The vitellaria consist of numerous small-sized follicles distributed in the posterior part of anterior body segment behind the ventral sucker. These never extend into the posterior body segment or anteriorly beyond the ventral sucker. The longitudinal vitelline ducts of the two sides bend inwards in the intertesticular region and join together medially to form a large elliptical vitelline reservoir. A short Laurer's canal could be made out in one of the mounted specimens as arising from the Mehli's gland complex and opening dorsally out in level of the posterior border of anterior testis. The Mehli's gland is situated submedially near the vitelline reservoir. Curiously I have not found any ascending limb of the uterus, as mentioned and illustrated by Narain, in my specimens. The uterus directly descends down and independently opens into the copulatory bursa at the base of the geital cones. Its walls are highly muscular and it has no connection whatsoever with the male genital ducts as described by Narain. The eggs are few in number. These are oval in shape and measure 0·0751—0·0976 mm. in length and 0·049—0·0677 mm. in breadth.

DISCUSSION

As mentioned above, this form belongs to the subfamily Polycotylinae Monticelli, 1888, because of the distribution of the vitelline follicles in the anterior segment of the body only. At present this subfamily includes, seven genera which fall into two distinct groups according to the association of various genital ducts. In one group which includes the genera *Polycotyle* Willemoes-Suhm, 1870, *Pseudocrocodilicola* Byrd and Reiber, 1942 and *Crocodilicola* Poche, 1925, the uterus, ejaculatory duct and the prostatic canal join together and form a hermaphroditic canal which opens into the copulatory bursa at the summit of a genital cone. In the second group, on the other hand, which includes the genera *Cystodiplostomum* Dubois, 1936, *Prolecithodiplostomum* Dubois, 1936, *Paradiplostomum* La Rue, 1926 and *Herpetodiplostomum* Dubois, 1936, the uterus and the ejaculatory duct join together to form a hermaphroditic canal which opens into the copulatory bursa independently of the prostatic canal which traverses through the genital cone and opens at its summit. The condition found in the present form is, altogether, different from both these above mentioned conditions. In the present case, the uterus opens independently into the copulatory barsa while the ejaculatory duct joins with the paraprostate. Further, anything comparable to the accessory genital cone of the present from is not recorded for any of the known genera of the subfamily Polycotylinae.

In view of these differences, the present from, hitherto known as < *Neodiplostomum gavialis* > can neither be considered as a member of the genus Crocodilicola Poche, 1925 as has been ascertained by Vidyarthi (1937) nor it can be included under any other

known genus of the subfamily Polycotylinae. I, therefore, propose for its reception, a new genus which I name as *Neelydiplostomum* nov. gen.

It is worthwhile to mention here that as far as the association of various genital ducts is concerned, this new genus closely approaches the condition found in the genera *Proterodiplostomum* Dubois, 1936 and *Pseudoneodiplostomum* Dubois, 1936, of the subfamily Proterodiplostomatinae Dubois, 1936.

DIAGNOSIS OF NEELYDIPLOSTOMUM nov. gen.

Polycotylinae:—Body elongated, morphologically distinctly bisegmented; anterior segment linguiform, about twice as long as posterior one; posterior segment almost cylindrical; suckers moderately well developed, oral smaller than ventral; tribocytic organ large, longitudinally oblong, with numerous small papillae on its inner margins; prepharynx and oesophagus short; pharynx well developed; intestinal caeca arcuate; testes large, occupy about 2/5 length of posterior segment in its anterior half, obliquely one behind the other, transversely stretched, anterior smaller than posterior one and is slightly sinistral; vescicula seminalis voluminous, coiled; ejaculatory duct opens into bulb-like part of weakly muscular paraprostate whose narrow duct-like part traverses through the substance of a large conical genital cone and opens at its summit into copulatory bursa; latter quadrangular and muscular, occupying last quarter of posterior segment; an accessory genital cone with a terminal swollen and constricted prepuce, present; ovary small, immediately pre-testicular, slightly dextral; Mehli's gland complex inter-testicular; vitelline follicles small, distributed in posterior half of anterior segment, behind ventral sucker; vitelline reservoir large, median; uterus short, narrow, muscular, without an ascending limb, opening independently into copulatory bursa at base of the genital cones; eggs few, oval; parasites of Crocodiles.

Type-species: —*Neelydiplostomum gavialis* (Narain, 1930) nov. comb.

AKNOWLEDGEMENTS

My sincere thanks are due to Dr. M. B. Lal of Lucknow University for his valuable help throughout the course of this work.

REFERENCES CITED

1. Bhalerao, G. D. 1942 "On Strigeida (Trematoda) from India," *Rec. Ind. Mus.*, 41 (2); 207-216.

2. Byrd, E. E. and Reiber, R. J 1942 "Strigeid Trematodes of the Alligator, with Remarks on the prostate glands and terminal portions of the genital ducts," *Jour. Parasitol*, 28 (1); 51-74.

3. Caballero, E. 1948 "Estudeos helmintologicos de la cuenca del rio Papaloapan, III. Strigeidos de los lagartos de Mexico. 2," *Ann. Esc. Nac. Cien. Bio.*, 5 (3-4); 217-221.

4. Dubois, G., 1938 "Monographie des Strigeida (Trematoda)" *Mem. Soc. neuch. Sci. nat.*, 6; pp. 535.

5. ———, 1944 "Un nouveau genre de Proterodiplostomidae (Trematoda) et une nouvelle cle de determination des diplostomes de Crocodiliens et de Cheloniens," *Rev. suisse Zool*, 51 (13); 356-360.

6. ———, 1951 "Nouvelle cle de determination des groupes systematiques et des genres de Strigeida Poche (Trematoda), *Ibid.*, 58 (39); 639-691.

7. ———, 1953 Liste systematique des Strigeida (Trematoda) de l' Inde," *Thapar Commemoration Volume*, pp. 77-88.

8. La Rue, G. R., 1926 "Stduies on the Trematode familly Strigeidae (Holostomidae), No. II. Taxonomy," *Trans. Amer. Micros. Soc.*, 45 (1); 11-19.

9. Narain, D., 1930 *Neodiplostomum gavialis* n. sp. from the Crocodile," *Jour. Parasitol.*, 16 (3); 154-157.

10. Vidyarthi, R. D 1937 "A new parasite of the genus *Proalarioides* Yamagauti, 1933 (Trematoda: *Proterodiplostomidae*), with a note on *Neodiplostomum gavialis* Narain, 1930," *Ann. Mag. nat. Hist.*, 20; 549-553.

A NOTE ON HELMINTHS OF THE INDIAN ELEPHANT (PART II). RECORD OF THE BURSATE WORMS OF THE FAMILY STRONGYLIDAE BAIRD, 1853

By

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There are records of helminthiasis in elephants associated with heavy infestations of bursate worms, particularly the hook worms. The pathogenic effects, it is believed, may also be contributed to by other species as well in cases of heavy infestations but such conditions may not possibly be detected in view of the difficulties of availability of carcase for a thorough post-mortem examination, as was the case with the present authors.

Adult bursate worms, belonging to eight species along with larval stages of two of these, under five known genera of the family, were collected from an Indian elephant that had died in August 1957 and a part of its intestine was available for this work. The specimens were killed in 70% hot alcohol and formalin and subsequently cleared in glycerine for study and identification. So far the parasites of this group from Indian elephant have been recorded and described by Evans and Rennie (1910), Lane (1914, 1915 and 1921), Ware (1924), Witenberg (1925), Bhalerao (1935) and these reports have been compiled by Yorke and Maplestone (1926) and Baylis (1936) in their books.

Baylis has included in the family Strongylidae six genera viz. *Strongylus* Muller, 1780; *Equinubria* Lane, 1914; *Choniangium* Railliet, Henry and Bauche, 1914; *Murshidia* Lane, 1914; *Khalilia* Neveu-Lemaire, 1924 (syn. *Amira* Lane, 1914) and *Quilonia* Lane, 1914. The first three have been placed in the subfamily Strongylinae Railliet, 1893 and the last two under Trichoneminae Railliet, 1916. In his treatment, Baylis has named all the nine species, then recoeded from elephant, as *Strongylus* (*Decrusia*) *additicius* Railliet, Henry and Bauche, 1914 (Syn. *Decrusia decrusi* Lane, 1914), recorded from the intestine of Indian elephant in Travancore; *Equinubria sipunculiformis* (Baird, 1859) Lane 1914; *Choniangium epistomum* Railliet, Henry and Bauche, 1914 (Syn. *Asifia vasifa* Lane, 1914), recorded from Bengal, *Choniangium species* Ware, 1924; *Murshidia murshida* Lane, 1914, from caecum of Indian elephant from various parts of India, *M. falcifera* (Cobbold, 1882) Lane, 1915, also recorded from various parts of India by Lane, from Burma by Evans and Rennie and from Andamans by Bhalerao, *M. indica* (Ware, 1924) Yorke and Maplestone, 1926 (Syn. *Pteridopharynx indica* Ware, 1924) from India and *Khalilia pileata* (Railliet, Henry and Bauche, 1914) (Syn. *Amira omra* Lane 1914; *Amira pileata* Lane, 1915).

Westhuysen (1938), in the classification of the nematodes in his monograph of the helminth parasites of the elephants, has included in all twelve species from Indian elephant in Strongylidae, viz., *Murshidia murshida, M. falcifera, M. indica, M. neveu-lemairei, M. lanei*; *Quilonia renniei* and *Q. travancra*; *Amira pileata*; *Choniangium epistomum, C. magnostomum*; *Equinubria sipunculiformis* and *Decrusia additictia*. The species, *C. magnostomum*, was described by him from an Indian elephant.

Other authors who have similarly compiled the available information and in some cases examined the litrature on these bursate worms are notably Sutherland *et al* (1950), Skrjabin *et al* (1952), Popova (1955) and Chabaud (1957).

Sutherland *et al* (1950) recorded *Murshidia murshida, Amira pileata, Equinubria sipunculiformis* and *Strongylus* (*Decrusia*) *additictus* from the post-mortem examination of a 14 year old Indian elephant that had died in quarantine and in this case of helminthiasis there was a very heavy infection with a species of hookworm which the authors believed to have caused the pathogenic effects and death.

Skrjabin *et al* (1952), in their survey of the group of bursate worms, classified the species recorded from Indian elephant and included in Strangylidae *Decrusia* with *D. addittctia*; *Equinubria* with *E. sipunculiformis*; *Choniangium* with *C. epistomum, C. magnostamum, C. species* and in the Trichonematidae Witenberg, 1925, *Amira* with *A. pileata*; *Murshidia* with *M. murshida, M. falcifera, M. indica M. lanei, M. neveu-lemairei*; *Quilonia* with *Q. renniei* and *Q. travancra.* Popova (1955), in the treatment of Strongylidae, includes under its sub-family Strongylinae, *Decrusia* with *D. additicta*; *Equinubria* with *E. sipunculiformis* and in Ransominae Travassos et Vogelsong, 1932, *Choniangium* with *C. epistomum, C. magnostomnm* and *C. species.* Gaafar and Turk (1950) recorded *Murshidia falcifera* from an Indian elephant that had been in the U.S.A. for forty years.

From the South India, in a survey of helminths of elephants, Ramanujachari and Alwar (1954) record in their checklist of parasites four genera, viz. *Murshidia* with five species *M. neveu-lemairei* (Witenberg, 1925), *M. linstowi*, Khalil, 1922, *M. hadia* Khalil 1922, *M. longicaudata* Neveu-lemaire 1928 and *M. brevicapsulatus* (Moning 1932); *Qulionia* with six species, *Q. africana* Lane 1921, *Q. Uganda* Khalil 1922, *Q. brevicauda* Khalil 1922, *Q. ethiopiea* Khalil 1922, *Q. Khalil* Neveu-Lemaire 1928 and *Q. magna* Neveu-lemaira (1928); *Choniangium* with *C. magnostomum* Westhuysen, 1938 and *Amira* with *A. sameera* Khalil 1922. Westhuysen, in his monograph, observes that the nematode parasites of the Indian and African elephants show a fairly strict host-specificity and no one species has been found which is common to both hosts. The joint authors from Madras, however, record from elephant in Madras four species of *Murshidia, M. linstowi, M. hadia, M. longicaudata* and *M. brevicapsulatus*; six species of *Qutlonia, Q. africana, Q. uganda, Q. brevicauda, Q. ethiopica, Q. khalil* and *Q. magna* and *Amria sameera* which are all reported from African elephant. The present authors also did not get any species recorded from African elephant in this collection.

The recent paper of Chabaud (1957) gives a critical review of the genera *Quilonia* and *Murshidia*, the former with two species, viz. *Q. travancra* and *Q. renniei* and the latter with four species, viz. *M. indica, M. neveulemairei, M. murshida* and *M. falcifera* from Asiatic elephant. The characters of all these species have been summarised and a key given. The genus *Mcrshidia* has been divided into two subgenera, *Pteridopharynx* and *Murshidia* and a new genus, *Neomurshidia* has been created. The Indian species assigned to subgenera *Pteridopharynx* are *P. indica* and to *Murshidia, M. neveulemairei, M. murshida* and *M. falcifera.* The first three species of *Murshidia* would now read as *Murshidia* (*Pteridopharynx*) *indica* (Ware 1924) *Murshidia* (*Murshidia*) *murshida* (Lane 1914) *Murshidia* (*Murshidia*) *falcifera* (Cobbold 1884)

On camparison of the specimens belonging to these eight species with the descriptions given by Baylis and Westhuysen, the differences, that have been observed

are in regard to certain measurements in relation to body length and size of eggs and are recorded in the following table.

Species		Measurement of the authors	Measurements by Baylis	Measurements by Westhuysen
1. *Murshidia (Pterido-pharynx) indica*	Male	19—21	15—18	16·7
	Female	22—24	19—22	21·2
	Egg	·084×·042	·06×·035	·056×·029
2. *Murshidia (Murshida) murshida* ...	Male	17—21	18—20	20—23
	Female	26—30	22—28	24— 8·2
	Egg	·063×·042	·072×·048 (Witenberg)	...
3. *Murshidia (Murshida) falcifera*	Male	22—25	22—27	22—28·8
	Female	27—30	24—32	29—36·6
	Egg	·075×·042	·05×·03 (Lane) ·084×·041 (Witenberg)	...
4. *Quilonia tranvancra*	Male	16—18	18	19·1
	Female	25·5	20	...
	Egg	·06×·043	·07×·045	...
5. *Quilonia renniei* ...	Male	...	15	...
	Female	27—32	20	...
	Egg	·069×·044	·075—0815×·0375 (Khalil)	...
6. *Choniangium epistomum*	Male	—	14	...
	Female	21	19	...
	Egg	·067×·042	·05×·025 (Lane)	...
7. *Decrusia additictia*	Male	16·5—19	14—20	...
	Female	22—24	15—24	17·20—21
	Egg	·069×·042	·065—·075×·04—·045	·08×·036
8. *Equinubria sipunculiformis* ...	Male	16—21	15	23-27
	Female	19—24	27·5	24—28
	Egg	·065×·037	·06×·03—·035	·063×·036

N. B.—All measurements are in m.m.

The authors are grateful to Dr. B. P. Pande, Professor, for his guidance and going through the manuscript. Thanks are due to Sri C. V. G. Choudary, Principal, for facilities, to Dr. H. D. Srivastava of I. V. R. I. for the loan of some literature and to Sri J. S. Srivastava for help in the collection of the worms.

REFERENCES

1. Bhalerae, G. D. (1935). Ind. J. Vets. Sc. Animal Husb. 5. 33-48.

2. Baylis, H. A. (1936) Nematoda I. The fauna of British India. Taylor and Francis, London, p.p. 408.

3. Chabaud, A. G. (1953) Ann de Parasit Hum et comp, 32, 28-131.

4. Evans, G. H. & T. Rennie (1910). Jour. Trop. Vet. Sci. Calcutta 5, 240-250.

5. Gaafar, S. M. & R. D. Turk (1956) J. Amer. Vet. Med. Assoc. 128, 84.

6. Lane, C. (1914), Ind. J. Med. Res. 2, 380-398.

7. ———(1915) *Ibid.* 3, 105-108.

8. ———(1921) *Ibid.* 9, 163-172.

9. Popova T.I. (1955) (Principles of nematology edited by K. I. Skrjabin V. Strongyloidea of Animals and Man, Strongylidae) Moscow; Izdatelstvo Akademii Nauk SSSR, pp. 223.

10. Skrjadin K. I., N. P. Shikhoblova, R.S. Schulz, T. I. Popova, S. N. Pocv & S. L. Delyamure (1952) (Descriptive Catalogue of parasitic nematodes III Strongyloidea) Moscow, Izdatelstvo Akademic Nauk SSSR, pp. 890.

11. Sutherland, A. K., P.J. O'Sullivan, & A. F. S. Ohman (1950) Aust. Vet. Jl. 26, 88-90.

12. Ware, F. (1924). J. Comp. Path Ther. 38, 83-89.

13. Westhuysen (1938). Onderst. Jl. Vel. Sc. & Anim. Hus. 10, 49-190.

14. Witenberg (1925). Parasitology 17, 284-294.

15. Wu, H. W. (1934). Sinensia Contributions from the Nat. Res. Inst. of Biol. Acad. Sinica 5 512-533.

16. Yorke, M. & P. A. Mapleston (1952). The nematode parasites of Vertebrates, London.

A NOTE ON COMMON HELMINTHS OF PIGS AT ALIGARH (PART I)

By

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Through the courtesy of the Manager, Central Diary Farm, Aligarh, an opportunity was afforded to collect the helminth parasites of pigs. Some specimens of a blood fluke, with a large number of an echinostome species, among the trematodes, along with many specimens of two species of stomach worms, an intestinal worm and the kidney worm, among the nematodes, were encountered. These were all suitably fixed and preserved for subsequent study.

Trematoda.—The two species of flukes have been studied from stained preparations of whole mounts and in one case from sections as well. The blood fluke is *Schistosoma incognitum* (Chandler, 1926), recently reported as quite a common parasite of pigs in Bareilly district by Sinha and Srivastava (1956), who have described this species in great detail and their account supplements the earlier description of this species by Rao and Aiyyar (1933) but under the name of *Schistosoma suis*, which is now its synonym. Our specimens agree in all respects with the description given by Sinha and Srivastava. Bhalerao (1931), while dealing with the trematode parasites of pigs in Bengal, recorded an echinostme under the name of *Paryphostomum surfrartyfex* (Lane, 1915), and, giving a detailed account of the parasite, also discussed its taxonomy, placing the genus *Paryphostomum* (Dietz, 1909), Bhalerao 1931, under the sub-family Himasthlinae (Odhner, 1911), Bhalerao 1931, of the Echinostomidae. This species had originally been desribed by Lane in 1915 as *Artyfec inostomum surfrartyfex* from a girl in assam and dealt with by Faust (1930) in his book as *Echinostoma surfrartyfex* (Lane, 1915). (Synonyms: *Artyfechinostomum surfrartyfex* (Lane, 1915), *Euparyphium malayanum* (Leiper, 1911) of Leiper 1914 and of Lane, 1924) while in the same work Faust separtely treated *Echinostoma malayanum* (Leiper 1911), obtained from intestine of Tamil coolie at Singapur and Kuala Lumpur, with *Euparyphium malayamum* (Leiper, 1911) as a synonym. Bhalerao (1935), in his helminth parasites of domesticated animals, while recording the species as parasite of man and pig, followed his earlier scheme of its classification. Mendhein (1943), however, retained Lane's genus *Artyfechinostomum* with two species, *A. surfrartyfex* and *A. malayanum*, which he distinguished on the number of collar spines, assigning it in the sub family Echinostominae. Faust (1949), in the recent edition of his book, has given the description of Lane's species, *Artyfechinostomum surfrartyfex*, based on Lane's study, the material from Indian museum and Bhalerao's material from Indian pigs as *Paryphostomum surfrartyfex* (Lane, 1915), (Synonyms—*Euparyphium malayanum* (Lieper, 1911) of Leiper 1924 and of Lane 1924, *Echinostoma surfrartyfex* (Lane, 1915) Faust 1929) but has dealt with separately the Malaya Fluke as *Echinostoma malayanum*, Leiper, 1911 (Synonym—*Euparyphium malayanum*) Baylis (1929) had, however, included Lane's species in the genus *Euparyphium* (Dietz, 1909) and also assigned to it the echinostome described by Leiper (1911) from the smaller intestine of man in Malaya Peninsula, pointing the differences between these two species. From Madras, Ramanujachari and Alwar (1954), have reported *Paryphostomum surfrartyfex* from pigs, while Peter (1954) has given a detailed

description of this species but under the name of *Artyfechinostomum surfrartyfex*. Thus, it would be evident that there is still controversy not only in regard to its nomenclature but also in its taxonomic position. The authors, after carefully comparing the descriptions of Bhalerao, Faust and Peter with the total preparations and the serial sections at their disposal, feel that some points particularly in regard to the head collar, its spines, extent and structure of cirrus sac, particularly the seminal vesicle, and the structure of terminal genitalia require to be added to the accounts given by these authors. It is, therefore, proposed to record herein a brief description, including remarks on the additional features, about this species of echinostome, the specimens with body dimensions larger than as far recorded-features about this species of echinostome which is also known to be associated with clinical symptoms in man, with the belief that this may help in elucidating its systematic position. In addition to another recent report of the *Paryphostomum surfrartyfex* infection in man by Reddy andVarmah (1950), there have been cases of other species of pig flukes recorded from human population, viz. *Fasciolopsis buski* in Bihar by Kant and Rama (1954) and the human amphistome, *Gastrodiscoides hominis*, reported in pigs but as a variety, var. *suis*, by Varma (1954). Buckley (1939), however, had also reported common occurrence of *Gastrodiscoides hominis* both in man and pigs in Kamrupa district of Assam.

Description.—The flukes, measuring 15—18 × 5—6 m. m. in size, in the mounted stained preparations, have a thick, fleshy and oblong body with a pinkish colour in the living state. In most cases, a constriction or notch on the sides of the ventral sucker was observed and the live worms were found active in body movements, particularly in the somewhat narrower anterior region of the body, and lived for 2—3 days in normal saline. The eggs, extruded by them, were preserved for taking the measurements. The cuticle is thick carrying prominent and pointed body spines mostly throughout the ventral surface. The head collar is reniform around the oral sucker and is continuous across its ventral surface by an 'isthumus'. There are in all 43 collar spines, of which 5 spines constitute the corner group and amongst these one is larger, one in each side, but the dorsal spines are arranged in two rows (Fig. 1). The prominent ventral sucker with a breadth of 1·8 m. m. on its anterior margin has its posterior part characteristically drawn out. The genital pore lies between the intestinal bifurcation and the ventral sucker. The testes are deeply lobed and situated in the posterior half of the body, the anterior testis being 2·3 × 1·7 m.m. and the posterior one 2·5 × 1·9 m.m. in size. The cirrus sac is muscular, considerably long and reaches posteriorly a little behind the hind margin of the ventral sucker. It has a coiled and tubular seminal vesicle leading into a highly convoluted pars prostatica and ejaculatory duct. (Fig. 2). The cirrus, when everted, is long and carries small-sized spines over it (Fig. 3). Ovary is pre-testicular but lateral and with a slightly lobate character, measuring 0·5 × 0·8 m.m. in size. Mehlis gland is of larger size than the ovary. There is no receptaculum seminis and the proximal coils of the uterus are mostly filled with dense masses of sperms. Laurer's canal is present. The uterine coils terminally end in a well-developed metraterm with thick muscular wall, muscle fibres being circular like that in the ejaculatory duct. Eggs, passed out by the worm, measure 0·12 × 0·08 m.m. in size. Viteline follicles, mainly extra caecal, commence from the middle of the ventral sucker meeting medianly behind the posterior testis.

From the foregoing description it would be evident that the notch observed in the live specimens had also been stated by Faust and Bhalerao. The continuity on the ventral surface of the head-collar, according to Bhalerao and Peter, was absent though Lane's figure shows its presence. Peter has given a detailed account of the head collar and the arrangement of the collar spines which number 43 and our observations agree with this author, though both Lane and Bhalerao gave the

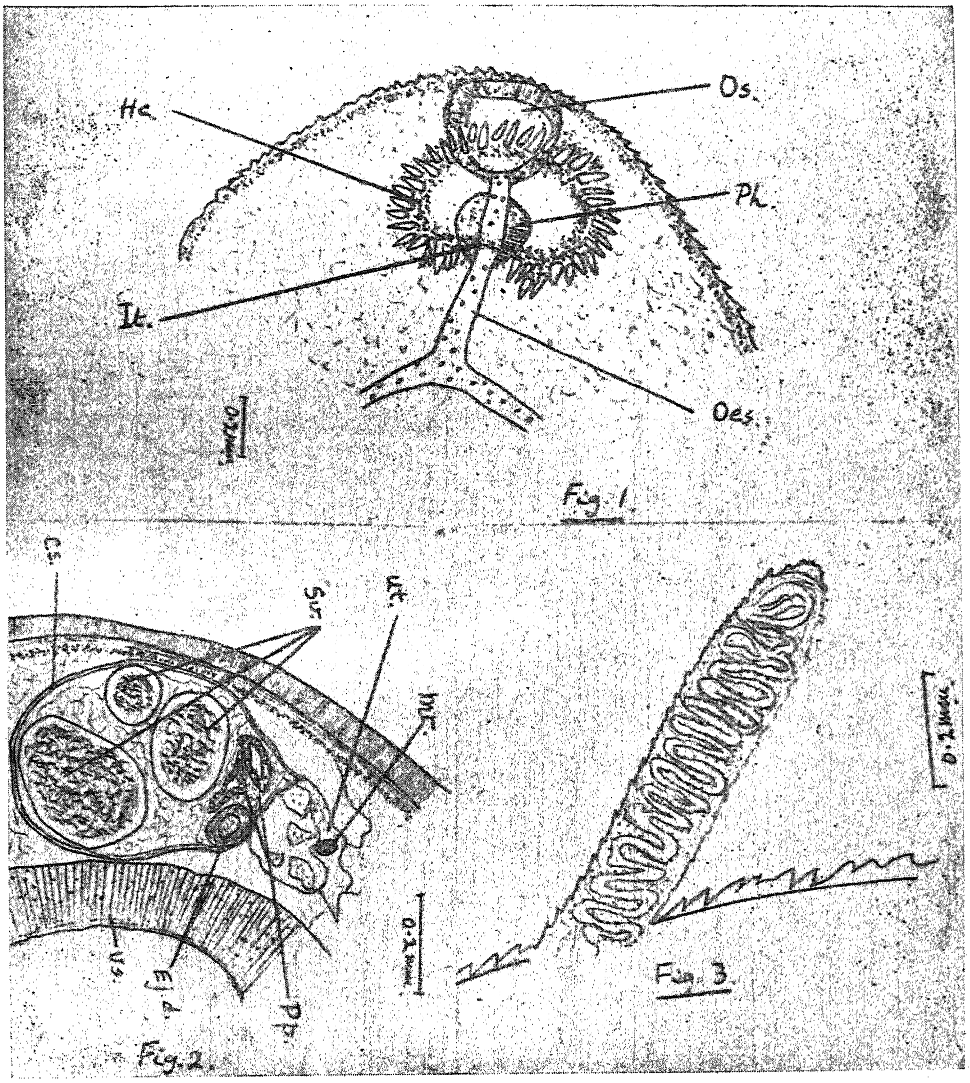

Fig. 1—Head collar with spines (diagramatic).

Fig. ·2—T. S. through ventral sucker and cirrus sac.

Fig. 3—Everted cirrus showing spinose character.

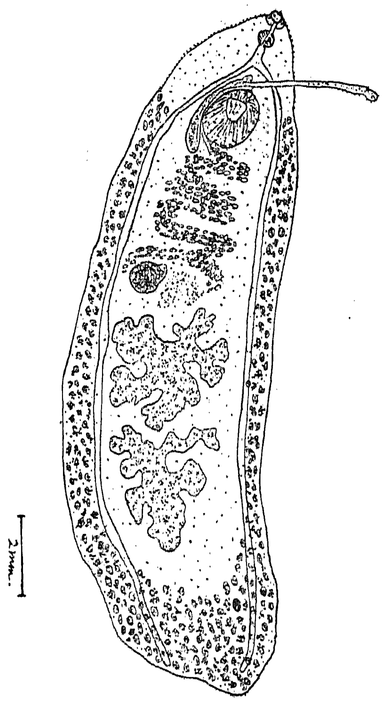

Fig. 4.

Fig. 4—Entire Specimen.

CS, Cirrus sac; Ejd, Ejaculatory duct; HC, Head collar;
It, Isthumus; Mt. Metraterm; Oes, Oesophagus; OS, Oral sucker;
Ph, Pharynx; Pp, Pars prostatica; Sv, Seminal vesicle;
Ut. Uterus; Vs, Ventral sucker.

number at 39—42 and the former stated the spines to be in one row. The spinose character of the cirrus has for the first time been observed, the previous authors Lane, Bhalerao and Peter, all described it as aspinose. In view of this it is felt that the forms so far described from pig and man under different specific names really belong to the species *Artyfechinostomum surfrartyfex* with no clear cut differences, if to the descriptions of the specimens, given by previous authors the additional information recorded herein is added. The Malaya fluke, *Echinostomum malayanum* (Lane, 1911), would also become a synonym of this species embracing all the forms so far recorded from pig and man.

The authors follow Mendhein in assigning the genus *Artyfechinostomum* to the sub-family Echinostominae.

Nematoda.—The four species in this group that have been collected are *Ascarops strongylina* (Rudoldhi, 1819), *Physocephalus sexalatus* (Molin, 1860), *Oesophagostomum dentatum* (Rudolphi, 1803) Molin (1861), and *Stephanurus dentatus* (Diesing, 1839). Adult specimens of the last species were obtained from the renal pelvis and peri-renal fat.

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REFERENCES

Baylis, H. A. (1929) A manual of Helminthology, Medical and Veterinary, Bailliere, Tindall and Cox London. 303 pages.

————(1936) The fauna of British India, Nematoda I Ascaroidea and Strongyloidea. Taylor and Francis, London 408 pages.

Bhalerao, G. D. (1931) Rec. Ind. Mus. XXXIII, 475-482.

————(1935) I. C. A. R. Scientific monograph No. 6.

Buckley J. J. C. (1939) Jour. Helm. XVII, 1-12.

————(1939) ————, 25-30.

Faust. E. C. (1930) Human Helminthology, London. pages 616.

————(1949) Human Helminthology, Philadelphia. pages 745.

Kant, L. and Rama K. (1954) Ind. Med. Gaz. 89, 89-94.

Lane, C. (1915) Ind Jour. Med. Res. II, 977-983.

————(1917) Ind. Jour. Med. Res. IV, 440-444.

Lapage, G. (1956) Monnig Veterinary Helminthology and Entomology. Baillier, Tindall and Cox London, pages 511.

Maplestone, P. A. (1930) Rec. Ind. Mus. XXXII, 77-105.

Mendhein, H. (1943) Arch. Fur. Natur. Bd. 12, 175-302.

Peter, C. T. (1954) Thesis for Ph. D. of Bombay University (Unpublished.)

Ramanujachari, G. and Alwar, V. S. (1954). Ind. Vet. Jour. 30, 490-500.

Rao. M. A. N. and Aiyyar, R. S. (1933) Ind. Jour. Vet. Sc. & A. H. 3, 321-324.

Reddy D. G. and Varmah, K. (1950) Ind. Med. Gaz. 85, 586-587.

Sinha, P. K. and Srivastava, H. D. (1950). Parasit. 46, 91-100.

Varmah, A. K. (1954) Ind. Jour. Med. Res. 42, 475-479.

STUDIES ON TOXIC EFFECTS OF HEPTACHLOR

By

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Heptachlor, a chlorinated hydrocarbon, has not been yet extensively studied. In the present paper an attempt has been made to study the action of heptachlor on the nervous system of weevils by calculating the variations in the duration of thanatosis which is a nervous response reported by several entomologists (Kozanshikov 1951, Robertson 1904, Holmes 1906 etc.) The author has already reported (Saxena 1958) that any chemical stimulant having its site of action, the nervous system, will bring about the changes in the priod of thanatosis. As it is necessary for the treated weevils to be in living condition in order to record the duration of thanatosis, sub-lethal doses of heptachlor were used. Further the toxicity of the insecticide film provided on filter paper was examined for 21 days. The assessment of the toxic effect was made by calculating the knockdown percentage.

MATERIAL AND METHOD

Desired concentrations of heptachlor were made by diluting it in the solvent (a mixture of analar petroleum ether and liquid paraffin mixed in the ratio of 4:1).

Calandra granaria L. not less then 10 days old, reared in the laboratory of Zoolgy Department of Saugar University, were used as test insects.

The methods, described in earlier papers (Saxena 1957a, 1958), for the application of the insecticide and the assessment of the toxic effect, were followed.

EXPERIMENTAL DESIGN

110 insects taken at random from the culture were divided into eleven equal batches which were treated with eleven different concentrations; 0·008%, 0·01%, 0·02%, 0·03%, 0·08%, 0·1%, 0·2%, 0·3%, 0·5%, 0·7%, and 1·0%. Four batches of insects of 10 each, treated with solvent, were run as control. The weevils were submitted for treatment for one hour and the response was recorded after an incubation period of 24 hours, during which the insects were supplied with wheat grains. The mean transformed durations were plotted against the log.concentrations on the graph.

For assaying three batches each of 20 insects were exposed to the filter papers impregnated with 0·5%, 1·0% and 2·0% heptachlor. The knockdown percentage was calculated after an exposure period of four hours. Two replicates each of 20 insects were run for each concentration. Toxicity filuctuations were measured in terms of concentration response regression lines. The films were tested on every fourth day.

RESULTS

Insects which normally show a duration of thonatosis of 4·0 seconds approx. exhibited an increase followed by a decrease in the duration from the normal value, on treating with different heptachlor concentrations. From the graph there appears

no change in the duration of thanatosis of the insects treated with 0·008%, on increasing the concentration upto a dose of 0·03%, the period increases, on further increase of the concentration the duration begins decreasing and falls to 0·28 second at 1·0% heptachlor treatment (Table 1. fig 1). Thanatosis response of the insects treated only with the solvent was unaffected (Table 1).

TABLE 1

Thanatosis response of *C. granaria* to heptachlor.

Transformed duration of thanatosis in seconds of the insects treated with.														
0·008%	0·01%	0·02%	0·03%	0·08%	0·1%	0·2%	0·3%	0·5%	0·7%	1·0%	CONTROL A	B	C	D
Mean duration of 10 insects														
1·97	2·28	2·61	2·95	2·3	2·04	1·5	1·33	0·94	0·76	0·28	1·82	1·9	2·1	1·92

External symptoms were also exhibited by the treated weevils. The insects treated with concentrations lower than 0·008% showed normal behaviour. Tremor of the legs and inco-ordinate locomotion were observed among the weevils treated with more than 0·1% heptachlor. Such insects were found facing a great dfficulty in moving straight. Many of such insects, which were found standing quietly on their legs after the lapse of the incubation period, when made to walk could move only for a few steps and then fell down on their backs, feebly waving their legs. They failed to right themselves and stand on their legs even when the help was provided. It appeared by their behaviour that they were able to feel and respond to the stimulus. The majority of insects treated with 1·0% heptachlor did not show death feigning behaviour as they normally do, instead tried to move away. In some cases the insects could not even feel the mechanical stimulus and remained as they were.

The succession of symptoms induced as a result of heptachlor treatment may be summarized as follows : —

I—Majority of insects show the normal behaviour even at increased duration of thanatosis. A little excitement is also exhibited by some treated weevils at this stage.

II—Excited stage. Movements become adnormally rapid. The period of thanatosis starts decreasing.

III—Progressive paralysis.Movements become slow and irregular and locomation inco-ordinate.

IV—Complete paralysis. No movement is exhibited unless the weevils are forced. Majority of insects in this stage die. Thanatosis could not be induced.

Toxicity of the heptachlor films provided on the filter paper was studied for 21 days. Insects were assayed against the films on every fourth day and toxicity fluctuations were measured in terms of concentration response regression lines (fig. 2). The median response concentrations calculated at different periods are tabulated thus :

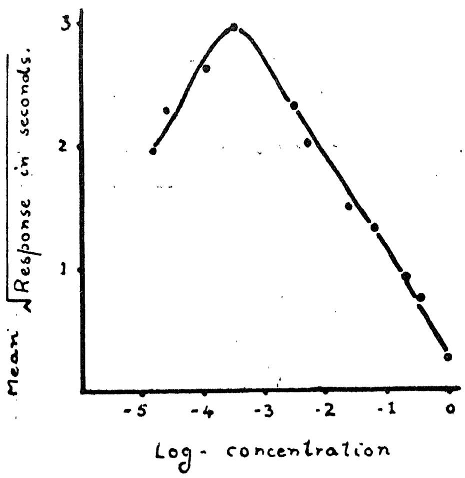

Fig. 1. Thanatosis response of *Calandra granaria* to heptachlor,

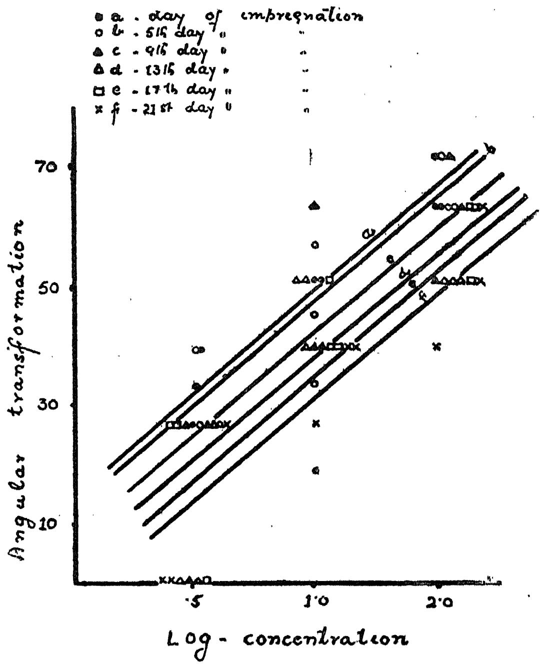

Fig. 2. Response of *C. granaria* to heptachlor film on different days of impregnation.

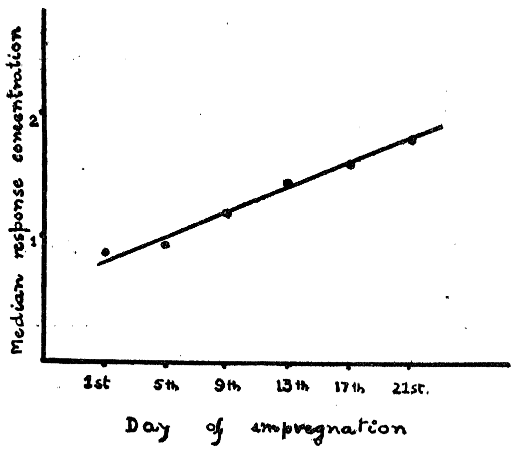

Fig. 3. Median response concentrations on different days of impregnation.

TABLE 2.

Median response concentrations at different periods

	1st day	5th day	9th day	13th day	17th day	21st day
Median response concn.	0·875%	0·94%	1·2%	1·44%	1·6%	1·8%

DISCUSSION

As a result of treatment with different heptachlor sublethal doses the duration of thanatosis is affected which shows an increase followed by a decrease till the value comes to less than one second (Fig 1). These changes may be discussed under the following heads :

(*a*) When duration of thanatosis is not affected.

(*b*) When duration of thanatosis increases.

(*c*) When duration of thanatosis decreases.

No change in the duration of thanatosis has been observed upto the treatment of insects with certain concentrations which are obviously very low. These concentrations may be called as uneffective concentrations. The author believes that on treating the insects with low concentrations, due to the slow absorption of the insecticide, no accumulation takes place and the insecticide at the site of action is kept down by metabolisation to such a harmless level that the duration of thanatosis and perhaps the transmission of impulses by nerves are not affected.

The increase in the duration of thanatosis results on treatment beyond the uneffective concentrations. Roeder and Weiant (1946, 1948) believe that exposure ofthe sense cells of the campaniform organs to DDT at concentrations as low as 0·01 p.p.m. may result in the production of repetitive trains of impulses in sensory nerves. The author thus suggests that at this level of concentration the accumulation of insecticide and initiation of a series of nervous impulses take place and the nervous system becomes already sensitized prior to the application of the mechanical stimulus applied to induce thanatosis. The impulses produced by the insecticide are superimposed on the nerves by the impulses produced as a result of the application of mechanical stimulus; obviously the effect of the mechanical stimulus in maintaining thanatosis is augmented and the duration of thanatosis thus increases.

The period of thanatosis decreases on treating the weevils with still higher concentrations. The decrease in the duration leads to the failure of the insects to respond the mechanical stimulus. Further increase in concentration results in death of the insect. Due to the increase in frequency of impulses transmitted the fatigue which is akin to that produced by repeatedly applying the mechanical stimulus to untreated insects (Saxena 1957, 1958*a*) at the relevent centres which become overstimulated. The insects thus fail to respond in the normal manner and show a decline in the duration of thanatosis which cannot be induced in the weevils having a treatment of high concentration of heptachlor.

Comparing the increase in the duration of thanatosis as a result of treatment with different insecticides, it appears that the magnitude of sensitization of the nervous system is higher when the insects are subjected to pyrethrum (Saxena 1958*b*) than to DDT (Saxena, in press). Heptachlor and BHC (Saxena, in press) sensitize the least and to the equal degree.

Further an attempt was made to study the duration of the toxicity of the heptachlor films provided on the filter papers. The lack of coincidence of regression lines represents the toxicity fluctuations of the films (Fig. 2). The increase in the median response concentration with the increase in the age of the films suggests the decline in the toxicity of the film (Fig. 3), which was quite effective even on 21st day of impregnation, although to a lesser degree than it was on 1st day. The lack of weevils prevented the testing of the film after 21 days of impregnation.

SUMMARY

It is suggested that the action of heptachlor upto a certain concentration is kept down by metabolisation to a harmless level, due to its slow absorption and failure to accumulate, at the site of action. Heptachlor at the concentration beyond this limit produces a train of sensory impulses which together with the impulses produced by the mechanical stimulation result in augmented thanatosis response. It appears that at still higher concentration a state similar to fatigue is reached resulting in the decline in thanatosis response.

A film of heptachlor provided on the filter paper was quite effective even on 21st day of its impregnation, but to a lesser degree than it was on 1st day.

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REFERENCES

Holmes, S. J.	(1906)	J. Comp. Neurol & Psychol. 16, 200.
Kozanshikov, I.	(1931)	Bull. Plant Protec, **111** (1).
Robertson, F. B.	(1904)	J. Physiol, **31**, 410.
Roeder, K. D.	(1953)	Insect Physiology.
Roeder, K. D. and E. A. Weiant.	(1946)	Science, **103**, 304.
————————	(1948)	Jour. Cellular and Comp. Physiol., **32**, 175.
Saxena, S. C.	(1957a)	J. Univ. Saugar, **6**, 90.
————————	(1957)	J. Zool. Soc. India, (in press).
————————	(1958b)	Proc. Nat. Acad. Sciences. **28** 27.
————————	(1958)	Indian J. Pharm. **20** (2), 40.
————————	(1958a)	Proc. Nat. Acad. Sciences. **28**, 41.
————————		Indian J. Entomol. (communicated).

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